Saskatchewan

A D F

Agriculture Development Fund

FINAL REPORT

19950327

IMPROVING NURSERY PRODUCTION OF CONTAINER AND FIELD-GROWN WOODY ORNAMENTALS

Funded by
The Agriculture Development Fund

March 2001

Prepared by: Saskatchewan Nursery Trades Association

SAF
Saskatchewan Agriculture & Food
Adding value to agriculture...through research and development

102-03940/

FINAL UPDATE to FINAL REPORT
ADF-95000327

IMPROVING NURSERY PRODUCTION OF CONTAINER- AND FIELD-GROWN WOODY ORNAMENTALS

LIBRARY
SASKATOON

FUNDED BY:
THE AGRICULTURE DEVELOPMENT FUND (ADF)
DUTCH GROWERS GARDEN CENTRE, LTD
LAKESHORE TREE FARMS, LTD

December 2000

Prepared by:
Erl Svendsen
Dr. Karen Tanino

Prepared for:
Saskatchewan Nursery Trades Association (SNTA)
685 Reid Rd.
Saskatoon, SK
S7N 3J4

SAF
SASKATCHEWAN AGRICULTURE AND FOOD

SASKATCHEWAN NURSERY TRADES ASSOCIATION

Title

Improving nursery production of container- and field-grown woody ornamentals

Project No:

95000327

Date of report completion:

20 February 2001

Principle investigator:

Tim Van Duyvendyk (president)
SNTA
685 Reid Rd.
Saskatoon, SK
S7N 3J4

Co-investigators:

I. Vic Krahn
Lakeshore Tree Farm Ltd.
Saskatoon, SK

ii. Karen Tanino
Dept. of Plant Sciences
University of Saskatchewan
51 Campus Dr.
Saskatoon, SK
S7N 5A8

Acknowledgements

Financial assistance was provided by Saskatchewan Department of Agriculture, Agriculture Development Fund (ADF). In kind funding (plant material, equipment, media, containers, labour, site maintenance, etc.) was shared between the two co-operators (Dutch Growers Garden Centre and Lakeshore Tree Farms). A generous donation of slow release fertilizer was supplied by The Scotts Company. Also, 'Indian Head' lentil was donated by Dr. A.E. Slinkard (Crop Development Centre, U of S, Saskatoon, SK) and 'Cuf 101' alfalfa seed was donated by Calwest Seeds (Woodland, CA) for use in the ground cover trials. The Department of Plant Sciences (U of S, Saskatoon, SK) provided lab, office and field space. A special thanks to Dr. Manjula Bandara who provided much needed assistance in statistical design and analysis for this project.

Abstract

The nursery industry in Saskatchewan is growing and consumer needs are changing. In order to meet the challenge of further expansion, growers need to become more efficient and evaluate and/or develop new technologies specific to prairie growing conditions. This includes evaluating new fertilizers, fertilizer timing, irrigation management techniques and weed control options both for field and container grown nursery stock. Over a period of 3 three years, a number of studies were initiated:

1) Evaluation of sulfur and acidifying fertilizers to reduce soil pH;
2) Evaluation of fertilizer rate, source and application method for Pot-in-Pot (PIP) caliper tree production;
3) Evaluation of fertilizer rate, source and application method for container production of shrubs;
4) Fertilizer comparisons from three manufacturers for container production;
5) Evaluation of a phosphorous soil inoculant (PB-50) for use in container shrub production;
6) Protocol evaluation of foliar nitrogen status assessment;
7) Media quality characteristic assessment;
8) Pre-emergent herbicide comparisons for container production;
9) Ground-covers for between-row weed control;
10) Water quality evaluation over the 1997 and 1998 growing season
11) Monitoring winter storage temperatures (1996 – 1998)
12) Nursery Production Literature Collection and Database;

Furthermore, irrigation water quality guidelines and media moisture monitoring systems were developed as information and management tools to assist nursery growers.

Summary

1) Soil pH modification and N-source fertilizer evaluation

Soil pH can be adjusted by using elemental sulfur but the changes occur slowly and are not apparent until after one full growing season. Acidifying fertilizers can also effectively and rapidly reduce soil pH but the effect is short-lived, lasting only one season. The sulfur rates used in this trial reduced caliper growth and so no recommendations with regards to sulfur use can be made at this time. Growers should, therefore, adopt acidifying fertilizers as their main weapon to counteract the pH-raising affects of irrigation.

2) Fertilizer Comparison Trial (PIP)

High fertilizer rates (> 2.5 lb N/yard^3) are unnecessary and may even be damaging to growth. Of more importance in PIP production is likely timely and sufficient irrigation.

3) Fertilizer Comparison Trial (shrubs)

High fertilizer (2.5 – 3.5 lb N/ yard^3) can reduce disease incidence (blackspot of rose), increase lateral branching, and increase overall quality in the species tested. One problem that may occur due to high fertility is lack of hardiness development at the end of the growing season and winter die-back or complete winter kill may negate the advantages of accelerated growth strategies.

4) Phosphorous soil inoculant (PB-50) in soil-less media

Neither the growth nor flowering of Morden Centennial rose was enhanced with the use of PB-50 at recommended rates. Late season leaf yellowing indicates that the controlled release fertilizer (Scott HighN 19-5-8) used in this trial may not have a long enough longevity under the irrigation conditions at Dutch Growers nursery.

5) Comparison of Foliar Nitrogen Status Evaluation Methods

Nitrate levels of petiolar sap provided a better indication of plant nutrient status than total nitrogen levels of leaves (as determined by mini-kjeldahl method). Petiolar sap nitrate levels, extracted either by macerating (blenderizing) petioles in water or freezing the petioles and then squeezing (freeze-&-squeeze), was measured using a hand-held ion-specific nitrate meter. There was a poor correlation between data sets. Since the freeze-&-squeeze method does not dilute or otherwise contaminate the sap, it is the preferable method for sap extraction. This technique requires further evaluation but it promises to be a relatively quick and low-cost alternative method for assessing plant nutrient status.

6) Media Quality Characteristics

Changes in pH, total nitrogen and nitrate levels, potassium levels, and electrical conductivity (EC) were monitored in pour-though leachate and ground media leachate over an entire growing season. Results suggest that total nitrogen (mini-Khjeldahl) may not be a good indication of fertility levels in media; pour-through leachate potassium levels can alert growers to low nutrient levels and is a better indicator of nutrient level than nitrogen; and initial pH adjustment of peat-based media may be unnecessary. Porosity characteristics were also measured over the growing season. Surprisingly, aeration porosity did not decline but remained within acceptable levels.

7) Herbicide Comparison Trial

Pre-emergent herbicide is becoming the weed control option of choice as container operations grow and labour costs increase. There are only 2 or 3 pre-emergent herbicides currently registered in Canada for nursery container production. Ronstar 2G (registered) and OH-II (non-registered) were evaluated for weed control efficacy. Both products controlled weeds equally well; however, OH-II achieved control at a much lower recommended active ingredient rate than Ronstar.

8) Ground-cover as Weed-control

Non-invasive, drought tolerant and slow growing ground cover is the ideal between-row weed control option in a field operation. Not only are weeds controlled with ground covers, but erosion is reduced, field accessibility is improved and fossil-fuel inputs are reduced. In our trial we found that annual alfalfa provided a good nurse crop until the grass cover was established. A grass mixture (25% kentucky bluegrass 'Ram 1' + 25% creeping red fescue (common) + 10% perennial ryegrass (common) + 20% chewings fescue 'Highlight' + 20% streambank wheatgrass 'Sodar') developed by the City of Saskatoon for their non-irrigated parks established quickly and required only 3 mowings during the growing season.

9) Media Moisture Monitoring System

There are no 'off-the-shelf' moisture monitoring systems commercially available. We have taken an electronic low-tension tensiometer (LT-RSU tensiometer; Irrometer Co.), suited to measuring water potential in soil-less media, and coupled it with a data logging and storage unit (LI-1000 datalogger; Licor, Inc.). The system was tested under field conditions and performed successfully. This system, with further modifications, could be used to monitor moisture status in containers and control irrigation events to coincide with predetermined moisture threshold levels to prevent drought stress.

10) Water Quality Monitoring (1997 & 1998)

Water quality is a critical component for any agricultural operation requiring irrigation. Over two growing seasons, water pH, total alkalinity, electrical conductivity and nitrate levels from 5 sources were measured weekly from June to October in 1997 and from May to October in 1998. All factors varied among sites and over time. The greatest changes in levels occurred after significant precipitation with pH and alkalinity dropping dramatically. Of the four factors measured, only alkalinity was consistently higher than recommended levels and it is the only

factor that poses any long-term threat to soil quality. An appendix on water quality, irrigation management strategies and methods & timing of irrigation delivery are provided.

11) Winter Storage Temperature Monitoring (1997 & 1998)

Winter root zone temperatures in pot-in-pot are comparable to soil temperatures and therefore should not require additional insulation to cover the in-ground containers. Insulated tarps are more effective than plastic+flax straw at minimizing the effect of extreme cold. Temperatures under the insulated tarps ranged between 0°C to -5°C and temperature shifts were gradual; temperatures under the plastic+straw ranged between 0 to -17°C and temperature shifts were rapid. Perennials stored in an unheated greenhouse and covered with a poly+microfoam+poly sandwich were never subjected to below 0°C during the storage period. The poorest survival occurred in small containers. The elevated temperatures (above freezing) may have contributed to poor survival by allowing disease an opportunity to establish or by increasing the respiration rate thereby depleting energy reserves before the end of storage. However, even under ideal winter storage conditions, there are variable rates of plant survival in containers depending on species and cultivars within species of typically hardy herbaceous perennials.

12) The Nursery Production Literature Collection (NPLC)

The NPLC is a collection of articles and selected book chapters covering a number of topics related to nursery production and relevant research techniques. This collection has been gathered over the past 4 years and contains nearly 1100 articles primarily from the last 20 years but some date back ~50 years. A bibliographical information database has been created to manage this collection and to allow easy retrieval of articles for growers, researchers and students. The database does not contain the entire collection yet, but once complete, the NPLC will be made available to the industry and other interested groups in the form of topic based lists. Two example lists are included.

NOTE: Full details from all trials except for "Soil pH modification and N-source fertilizer evaluation" and "The Nursery Production Literature Collection (NPLC)" can be found in the April 1999 report. The ADF board granted a continuation of this project using existing funds to continue monitoring the "Soil pH modification and N-source fertilizer evaluation" trial and to continue updating the NPLC.

Table of Contents

Abstract iii
Summary iii
1. Soil pH modification and N-source fertilizer evaluation iii
2. Fertilizer Comparison Trial (PIP) iv
3. Fertilizer Comparison Trial (shrubs) iv
4. Phosphorous soil inoculant (PB-50) in soil-less media iv
5. Comparison of Foliar Nitrogen Status Evaluation Methods iv
6. Media Quality Characteristics iv
7. Herbicide Comparison Trial v
8. Ground-cover as Weed-control v
9. Media Moisture Monitoring System v
10. Water Quality Monitoring (1997 & 1998) v
11. Winter Storage Temperature Monitoring (1997 & 1998) vi
12. The Nursery Production Literature Collection (NPLC) vi

Soil pH modification and N-source fertilizer evaluation **1**

Introduction 1
Experiment 1: Soil pH adjustment using elemental sulfur and acidifying fertilizers 2
Discussion 19
Conclusions 23
Experiment 2. Soil pH adjustment using only elemental sulfur 24
Discussion & Conclusions 25
Bibliography 28

The Nursery Production Literature Collection (NPLC) **31**

Topic Based Lists (Numbers correspond to ID number in PNLC database) 32
Index: The PNLC electronic database can be searched using up to any three of the following keyword terms to produce a client requested topic list 38
The Prairie Nursery Literature Collection – ID number, Citation and Abstract 56

Soil pH modification and N-source fertilizer evaluation

Introduction

Common problems that growers in alkaline soil zones face are nutritional disorders such as chlorosis, purpling of leaves or poor vigour of their field grown stock. Although initially appearing to be the result of a lack of iron, magnesium or other minor nutrients, the more likely cause is the unavailability of these nutrients to plants due to high soil pH (>7.5), typical of prairie agricultural soils. Furthermore, using a high bicarbonate water source for irrigation can lead to higher soil pH and alkalinity problems (Slaton *et al.* 1997). Applying micronutrients on a field scale whether directly to the soil or, as a foliar spray is both expensive and only treats the symptom and not the underlying cause and is therefore of short-term value.

The adverse effects due to high soil pH can be alleviated by 1) relocating the operation to an area with neutral to slightly acid soils or 2) adjusting the soil pH with acidifying agents (Cowling and Clements 1993). The first method is neither practical nor possible in the grain belt or parkland areas of the prairie region. The second method can be accomplished by using either acidifying fertilizers or elemental sulfur (S^0) (Table 1) (Barak *et al.* 1997, Ali and Stroehlein 1991, Beverly and Anderson 1987, Janzen and Bettany 1987, Chapman 1936).

Acidifying fertilizers can be used as a short-term solution (Beverly and Anderson 1987). Since the soil is a highly buffered system, applying a relatively small amount of acidifying fertilizer to supply nitrogen (N) and phosphorous (P) to satisfy the crop's needs will only modify the immediate zone of fertilizer placement for a short time (i.e. less than one season); however, the pH change is immediate.

Table 1. Acidifying Fertilizers

	N-P-K(-S)
Ammonium nitrate	34-0-0
Ammonium sulfate	21-0-0-24
Ammonium thiosulfate	12-0-0-26
Diammonium phosphate	21-52-0
Gypsum	0-0-0-17
Magnesium ammonium phosphate	7-40-6
Monoammonium phosphate	12-51-0-1.5
Phosphoric acid	0-52-0
Single superphosphate	0-20-0-12
Sulfur coated urea (SCU)	35-0-0-24
Sulfur, elemental (S^0)	0-0-0-90

Broadcast application of S has a lasting affect but may take at least one growing season before any benefit is noticed (Messenger and Nesbit 1998). Broadcast application of S will only acidify the top 15 - 30 cm of the soil (Mahler 1986) and the pH in lower soil zones may rise because cations (positively charged ions) from the acidified zone are displaced downward creating a zone rich in calcium, magnesium and other cations (Whitcomb 1986). This should not be of any great concern to the grower, however, as the majority of fine roots (primary site of nutrient absorption) are in the top few centimeters of the soil, and the plant will benefit from the greater availability of nutrients (Messenger 1984, Whitcomb 1986). Long-term studies have shown that pH can be driven down by more than 1 pH value and that this effect can last at least 10 years following a single application (Whitcomb 1987). Typical rates required to adjust soil pH down are in the order of 1100 kg/ha (1000 lb./ac) (Beverly 1987, Remon *et al.* 1977); fortunately, S is inexpensive and its effect on soil pH is long lasting.

Soil pH adjustment field trials

Experiment 1: Soil pH adjustment using elemental sulfur and acidifying fertilizers

The purpose of this experiment was to determine the effect of applying a combination of elemental sulfur and acidifying fertilizers on soil pH and plant productivity. Two trials were initiated at each of two sites. The first trial was started in spring, 1996 and the second, a duplication of the first trial but with different plant species, in 1997. These trials will be monitored through to the fifth year of the project; however, the inherent nature of this experiment requires longer-term observation.

Materials & Methods

Sites

1. DG = Dutch Growers Garden Centre, Ltd. (production farm: Beaver Creek); clay soil
2. LS = Lakeshore Tree Farm, Ltd. (production farm: Moonlake); clay soil

Main treatment (irrigation treatments were only applied at Dutch Growers)

Irrigation type

1) Overhead

2) Drip

Secondary treatment

Sulfur [Tiger 0-0-0-90] application (one time broadcast application at planting)

A) 0 kg/ha (0 lb./ac)

B) 975 kg/ha (870 lb./ac)

C) 1950 kg/ha (1740 lb./ac)

Tertiary treatment+, ‡

Fertilizer application (broadcast application of 90 kg N/ha [80 lb. N/ac])

a) ammonium sulfate (21-0-0-24) split application

b) 40% SCU + 60% urea (35-0-0-8)

c) Topdress + Minors (17-3-6-16)

+ At Lakeshore, fertilizer treatments were only applied in the year of planting (see below) and in subsequent years, standard site nursery practice was followed; Dutch Growers, fertilizer treatments were applied each year from the year of planting up to and including 1999.

‡ These fertilizers were chosen because they supplied primarily nitrogen with some additional sulfur

Species:

DG Colorado spruce; *Picea pungens* (1996*)

Fallgold Ash; *Fraxinus nigra* 'Fallgold' (1996*)

Thunderchild crab; *Malus* x 'Thunderchild' (1996*)

Advance Ash; *Fraxinus* x 'Advance Ash' (1997*)

Mancana Ash; *Fraxinus* x 'Mancana' (1997*)

Northwood Maple; *Acer rubra* 'Northwood' (1997*)

LS Colorado spruce; *Picea pungens* (1996*)

Fallgold Ash; *Fraxinus nigra* 'Fallgold' (1996*)

Princess crab; *Malus* x 'Princess' (1996*)

Advance Ash; *Fraxinus* x 'Advance Ash' (1997*)

Thunderchild crab; *Malus* x 'Thunderchild' (1997*)

*year in which planted

Measurements:

Soil was sampled to a depth of 15 cm twice/season on July 7 1997, September 24 1997, May 5 1998, October 1 1998, June 11 1999, October 14 1999, May 17 2000 and September 1 2000. Samples were taken from within the row 30 – 60 cm from either side of the centre tree in each treatment combination. Soil pH was determined by mixing 50 g of soil with 100 ml distilled water, allowed to sit for 5 minutes followed by stirring while measuring pH. Caliper was measured at 30 cm above grade at planting and on June 25 1997, November 4 1997, October 8 1998, October 14 1999 and September 1 2000. Leaf samples (10 from each tree) were collected on August 22 1997 and weighed before and after drying. Growth index determinations of spruce were calculated the following formula: H*(W1 + W2)/2, where H = height (cm); W1 and W2 = two widths (maximum) measured perpendicular to one another. Height and width was measured in June 1996, June 1997, November 1997, October 1998, October 1999 and September 2000.

Experimental Design

Treatments were arranged in a split split plot in a Randomized Complete Block Design (RCBD) with irrigation as main plot, sulfur level as sub plot and fertilizer source as sub-sub plot at Dutch Growers (site 1) and sulfur as main plot and fertilizer as sub plot at Lakeshore (site 2). There were three trees per treatment and treatments were replicated four times. Both sulfur and fertilizer were broadcast within row without incorporation. Growth data was tested using General Linear Model (GLM) and initial measurements were used as a covariate to account for variation in the planting stock. Soil pH data was tested using ANOVA without covariate analysis. Treatment means were compared using least significant difference (LSD) whenever the F-tests for treatments were significant at $p \leq 0.05$. Trend analysis with respect to sulfur rates and

caliper development or soil pH changes was performed to test for linear or other relationships. Soil pH outside the treatment area was measured to assess the changes in pH over the season. This data was not included in the analysis but has been presented for reference purposes only (Table 2).

1996 Trial

Sulfur was applied directly after planting in 1996; fertilizer treatments were applied in 1996, 1997, 1998 and 1999 at DG but only at planting time at LS. The reason for this difference was to assess the long-term effect of applying an acidifying fertilizer. Ammonium nitrate (fertilizer treatment 'a') application was split, with half applied in May and the other half in July (45 kg N/ha [40 lb. N/ac] at each application). The other fertilizer treatments (treatments 'b' and 'c') were applied in May.

1997 Trial

Sulfur was applied directly after planting, followed by fertilizer application as above for 1996.

Results

1996 trial (1996 – 2000)

Soil pH

Lakeshore:

Sulfur treatments applied in 1996 did not begin to have an effect on soil pH until the fall of 1997 when there was a significant ($p \leq 0.05$) linear decrease in soil pH with increasing amounts of sulfur. Differences among sulfur treatments were not significant at either sampling period. There was no significant change in soil pH due to fertilizer applied in 1996 at Lakeshore (Table 3).

Dutch Growers:

There was a significant ($p \leq 0.05$) linear decrease in soil pH with increasing amounts of sulfur by spring 1997 and a highly significant ($p \leq 0.01$) linear decrease by fall 1997 which continued to be evident at the end of the 1998 growing season. In June 1999, the linear trend was not as

significant as the quadratic trend and this was due to the elevated pH levels in treatment B (875 kg S/ha). In October 1999 and May 2000, no significant trends were detectable. In September 2000, there was a significant ($p \leq 0.01$) quadratic trend with respect to soil pH in response to a linear increase in sulfur rates (i.e. soil pH was elevated in treatment B relative to treatments A and C). Sulfur treatment C (1950 kg S/ha) caused soil pH to drop significantly ($p \leq 0.05$) more than either sulfur treatments A (0 kg S/ha) or B (875 kg S/ha) in September 1997 and June 1999. This difference was not significant in October 1998, October 1999 or May 2000. In September 2000, soil pH was significantly ($p \leq 0.05$) lower in treatment C than in treatment B. All other treatment mean comparisons were statistically equivalent (Table 4a).

There was a significant ($p \leq 0.01$) difference among fertilizer treatments in the spring of 1997 where fertilizer treatment 'c' (Topdress + Minors) was the most effective fertilizer source in reducing soil pH. The other two treatments were equivalent. In the fall, 1997, fertilizer treatment 'a' (ammonium sulfate) was significantly ($p \leq 0.05$) more effective than treatments 'b'. Irrigation scheme did not affect soil pH (data not shown). (SCU + urea) or 'c' (Topdress + Minors). Treatments 'b' and 'c' were equivalent. There were no significant differences among fertilizer treatments in 1998, 1999 or 2000 (Table 4a).

M121

IMPORTANT NOTE CONCERNING THE FOLLOWING PAGES

THE PAGES WHICH FOLLOW HAVE BEEN FILMED TWICE IN ORDER TO OBTAIN THE BEST REPRODUCTIVE QUALITY

USERS SHOULD CONSULT ALL THE PAGES REPRODUCED ON THE FICHE IN ORDER TO OBTAIN A COMPLETE READING OF THE TEXT.

REMARQUE IMPORTANTE CONCERNANT LES PAGES QUI SUIVENT

LES PAGES SUIVANTES ONT ÉTÉ REPRODUITES EN DOUBLE AFIN D'AMÉLIORER LA QUALITÉ DE REPRODUCTION

LES UTILISATEURS DOIVENT CONSULTER TOUTES LES PAGES REPRODUITES SUR LA FICHE AFIN D'OBTENIR LA LECTURE DU TEXTE INTÉGRAL

Micromedia
ProQuest

20 Victoria Street
Toronto, Ontario M5C 2N8
Tel.: (416) 362-5211
Toll Free: 1-800-387-2689
Fax: (416) 362-6161
Email: info@micromedia.on.ca

Table 2. Soil pH sampled from adjacent non-treated nursery rows for non-statistical comparison and for monitoring soil pH changes over time and between sites.

	Sampling Date							
Site[a]	May, 1996	May, 1997	June, 1997	Sept., 1997	June, 1999	Oct., 1999	May, 2000	Sep., 2000
				8.0				
DG	7.8	8.0	7.9	8.1	7.73	7.85	7.80	7.68
DG		8.0	7.9	8.0	7.79	7.60	7.67	7.65

a - LS = Lakeshore Tree Nursery (Moonlake field production farm); DG = Dutch Growers Nursery (Beaver Creek field and container production farm)

Table 3. Lakeshore (1996 trial;): Fallgold Ash soil pH response to sulfur and fertilizer application (1997)

	Soil pH	
Treatment	May 1997	Sept. 1997
Sulfur B (975 kg S/ha)	7.72	8.01
Fertilizer a (ammonium sulfate)	7.79	8.01
Fertilizer c (Topdress + minors)	7.78	8.06
signif. (sulfur)	ns	+
CV % (sulfur)	1.9	1.4
LSD (fertilizer)	-	-
Trend Analysis (sulfur)[‡]		
quadratic	ns	ns

[‡]ns; + or * = not significant; significant at $p \leq 0.10$ or 0.05, respectively

Table 2. Soil pH sampled from adjacent non-treated nursery rows for non-statistical comparison and for monitoring soil pH changes over time and between sites.

		Sampling Date							
	Site[a]	May, 1996	May, 1997	June, 1997	Sept., 1997	June, 1999	Oct., 1999	May, 2000	Sep., 2000
1996 Sulfur Trial	LS	7.8	8.1	8.1	8.0				
	DG	7.8	8.0	7.9	8.1	7.73	7.85	7.80	7.68
1997 Sulfur Trial	LS		8.1	8.1	8.3	7.72	7.80	7.78	7.80
	DG		8.0	7.9	8.0	7.79	7.60	7.67	7.65

a - LS = Lakeshore Tree Nursery (Moonlake field production farm); DG = Dutch Growers Nursery (Beaver Creek field and container production farm)

Table 3. Lakeshore (1996 trial;): Fallgold Ash soil pH response to sulfur and fertilizer application (1997)

	Soil pH	
Treatment	May 1997	Sept. 1997
Sulfur A (0 kg S/ha)	7.81	8.07
Sulfur B (975 kg S/ha)	7.72	8.01
Sulfur C (1950 kg S/ha)	7.74	7.93
Fertilizer a (ammonium sulfate)	7.79	8.01
Fertilizer b (40% SCU + 60 % urea)	7.71	7.95
Fertilizer c (Topdress + minors)	7.78	8.06
Statistical Significance[‡]		
signif. (sulfur)	ns	+
LSD (sulfur)	-	0.09
CV % (sulfur)	1.9	1.4
signif. (fertilizer)	ns	ns
LSD (fertilizer)	-	-
CV % (fertilizer)	1.5	1.6
Trend Analysis (sulfur)[‡]		
linear	ns	*
quadratic	ns	ns

[‡]ns; + or * = not significant; significant at $p \leq 0.10$ or 0.05, respectively

Growth Measurements (Caliper, Leaf Dry Weight, Growth Index)

Dutch Growers

Spruce: There were no significant differences among growth index means in response to sulfur levels. There was a slightly significant ($p \leq 0.10$) linear decrease in growth index in June 1997 and October 1998 and a significant ($p \leq 0.05$) linear decrease in November 1997 in response to a linear increase in sulfur rates (Table 5).

Fallgold Ash: There was a significant ($p \leq 0.05$) interaction of irrigation x sulfur level on leaf dry weight. Under overhead irrigation, there was no response to sulfur level; under drip irrigation, sulfur treatments B (975 kg S/ha) resulted in a lower leaf dry weight than from either sulfur treatment A (0 kg S/ha) or C (1950 kg S/ha) (Table 6). There was no significant response to other treatments or to other interactions among treatments with respect to leaf dry weight.

Irrigation had a significant ($p \leq 0.05$) effect on percent caliper change between June 1997 and November 1997. Tree caliper under drip irrigation increased significantly ($p \leq 0.05$) more than under overhead irrigation (Table 7). [Note: Leaf dry weight was also higher under drip irrigation than under overhead irrigation; however, the difference was non-significant (Table 6).] There were no other significant effects on percent caliper change due to treatment or interactions among treatments (Table 4b).

Thunderchild Crab: Trees planted in the drip irrigation treatments were one grade size smaller than those planted in the overhead irrigation treatments. Also, the smaller trees suffered from a higher level of winter injury than the larger trees during last winter (winter 96-97). For these reasons, Thunderchild crab was removed from the trial.

Table 4a. Dutch Growers (1996 trial): Fallgold Ash soil pH response to sulfur and fertilizer application (1997 – 2000)

Treatment	Soil pH							
	May, 1997	Sept. 1997	May, 1998	Oct., 1998	June, 1999	Oct., 1999	May 2000	Sept. 2000
Sulfur B (975 kg S/ha)	7.84	7.97	7.82	7.54	7.92	7.76	7.74	7.52
Fertilizer a (ammonium sulfate)	7.87	7.84	7.84	7.51	7.80	7.77	7.65	7.45
Fertilizer c (Topdress + minors)	7.76	7.96	7.83	7.54	7.85	7.73	7.68	7.45
signif. (sulfur)	+	*	ns	ns	*	ns	ns	*
CV % (sulfur)	1.7	1.1	1.4	0.7	0.2	2.0	2.1	0.8
LSD (fertilizer)	0.09	0.11	-	-	-	-	-	-
Trend Analysis (sulfur) ‡								
quadratic	ns	ns	ns	ns	**	ns	ns	**✓

‡ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively; The check mark (✓) indicates the most significant trend (by calculated F-value) when significance levels appear the same.

Table 4a. Dutch Growers (1996 trial): Fallgold Ash soil pH response to sulfur and fertilizer application (1997 – 2000)

Treatment	Soil pH							
	May, 1997	Sept. 1997	May, 1998	Oct., 1998	June, 1999	Oct., 1999	May 2000	Sept. 2000
Sulfur A (0 kg S/ha)	7.92	7.98	7.90	7.57	7.85	7.72	7.70	7.46
Sulfur B (975 kg S/ha)	7.84	7.97	7.82	7.54	7.92	7.76	7.74	7.52
Sulfur C (1950 kg S/ha)	7.73	7.81	7.78	7.50	7.75	7.76	7.65	7.40
Fertilizer a (ammonium sulfate)	7.87	7.84	7.84	7.51	7.80	7.77	7.65	7.45
Fertilizer b (40% SCU + 60 % urea)	7.87	7.96	7.83	7.56	7.87	7.74	7.76	7.49
Fertilizer c (Topdress + minors)	7.76	7.96	7.83	7.54	7.85	7.73	7.68	7.45
Statistical Significance[†]								
signif. (sulfur)	+	*	ns	ns	*	ns	ns	*
LSD (sulfur)	0.11	0.10	-	-	0.09	-	-	0.07
CV % (sulfur)	1.7	1.1	1.4	0.7	0.2	2.0	2.1	0.8
signif (fertilizer)	**	*	ns	ns	ns	ns	ns	ns
LSD (fertilizer)	0.09	0.11	-	-	-	-	-	-
CV % (fertilizer)	0.9	1.5	1.1	1.3	1.0	1.2	1.1	0.8
Trend Analysis (sulfur)[‡]								
linear	*	**	**	**	*	ns	ns	**
quadratic	ns	ns	ns	ns	**	ns	ns	**✓

[†]ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively; The check mark (✓) indicates the most significant trend (by calculated F-value) when significance levels appear the same.

Table 4b. Dutch Growers (1996 trial): Fallgold Ash caliper response to sulfur and fertilizer application (1997 – 1999)

Treatment	Caliper (cm)				
	June, 1997	Nov., 1997	Oct., 1998	Oct., 1999	Sept., 2000
Sulfur A (0 kg S/ha)	2.36	2.99	4.00	5.68	6.86
Sulfur B (975 kg S/ha)	2.22	2.89	3.90	5.45	6.77
Sulfur C (1950 kg S/ha)	2.31	3.00	3.98	5.87	7.15
Fertilizer a (ammonium sulfate)	2.33	3.00	4.02	5.69	6.85
Fertilizer b (40% SCU + 60 % urea)	2.30	3.02	4.12	5.95	7.39
Fertilizer c (Topdress + minors)	2.25	2.86	3.74	5.35	6.55
Statistical Significance[‡]					
signif. (sulfur)	ns	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-	-
CV % (sulfur)	15.4	21.1	21.1	22.1	18.4
signif (fertilizer)	ns	ns	ns	ns	ns
LSD (fertilizer)	-	-	-	-	-
CV % (fertilizer)	10.1	10.5	10.5	11.8	12.5
Trend Analysis (sulfur)[‡]					
linear	ns	ns	ns	ns	ns
quadratic	ns	ns	ns	ns	ns

[‡]ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Table 5. Dutch Growers (1996 trial): Spruce growth index response to sulfur and fertilizer application (1997 – 1998)

Treatment	Growth Index[†]				
	June, 1997	Nov., 1997	Oct., 1998	Oct., 1999	Sept., 2000
Sulfur A (0 kg S/ha)	4090	5120	8400	13852	19694
Sulfur B (975 kg S/ha)	3920	4870	7940	12534	19366
Sulfur C (1950 kg S/ha)	3870	4770	7770	12409	18761
Fertilizer a (ammonium sulfate)	3900	4730	7840	12601	19161
Fertilizer b (40% SCU + 60 % urea)	3950	5090	8140	12753	18709
Fertilizer c (Topdress + minors)	4000	4940	8130	13171	19951
Statistical Significance[‡]					
signif. (sulfur)	ns	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-	-
CV % (sulfur)	9.8	10.8	13.9	16.9	12.0
signif (fertilizer)	ns	ns	ns	ns	ns
LSD (fertilizer)	-	-	-	-	-
CV % (fertilizer)	7.9	10.2	13.3	13.1	13.8
Trend Analysis (sulfur)[‡]					
linear	+	*	+	ns	ns
quadratic	ns	ns	ns	ns	ns

[†]growth index = height x average maximum width

[‡]ns; + or * = not significant; significant at $p \leq 0.10$ or 0.05, respectively

Table 6. Dutch Growers (1996 Trial): Fallgold Ash leaf dry weight response to the interaction effect of irrigation x sulfur treatment

Irrigation	Sulfur level	Leaf Dry Weight (g)
Overhead	A (0 kg S/ha)	1.5
	B (975 kg S/ha)	1.7
	C (1950 kg S/ha)	1.6
Drip	A (0 kg S/ha)	2.4
	B (975 kg S/ha)	1.8
	C (1950 kg S/ha)	2.4
LSD (0.05) [between sulfur levels at one irrigation level]		0.4

Table 7. Dutch Growers (1996 Trial): Fallgold Ash percent caliper change from June 1997 to November 1997 in response to irrigation scheme

Irrigation	Caliper change (%) (June 1997 - Nov. 1997)
Overhead	18.2
Drip	25.2
LSD (0.05)	2.5

1997 Trial (1997 – 2000)

Soil pH

Dutch Growers (site 1)

Sulfur was ineffective at significantly reducing soil pH in the first season. There was a highly significant ($p \leq 0.01$) linear decrease in soil pH in response to a linear increase in sulfur rates in October 1998. In June 1999, there was a significant ($p \leq 0.01$) quadratic trend with respect to pH response to increasing sulfur rates. This was a result of the soil pH being significantly ($p \geq 0.05$) higher in treatment B (975 kg S/ha) than in treatment C (1950 kg S/ha) and non-significantly higher than treatment A (0 kg S/ha). At the end of the 3rd growing season (October 1999) there was a significant ($p \geq 0.05$) increase in soil pH in response to increasing sulfur rates. In 2000 there were no significant differences or trends among sulfur treatments with respect to soil pH (Table 8a).

Fertilizer treatment 'a' (ammonium sulfate) significantly ($p \leq 0.01$) reduced soil pH more than either of the other two treatments in the first season. Fertilizer treatments 'b' (SCU + urea) and 'c'

Table 4b. Dutch Growers (1996 trial): Fallgold Ash caliper response to sulfur and fertilizer application (1997 – 1999)

Treatment	Caliper (cm) June, 1997	Nov., 1997	Oct., 1998	Oct., 1999	Sept., 2000
Sulfur A (0 kg S/ha)	2.36	2.99	[illegible]	[illegible]	[illegible]
Sulfur B (975 kg S/ha)	2.22	2.89	3.90	5.45	6.77
Sulfur C (1950 kg S/ha)	2.31	3.00	[illegible]	[illegible]	[illegible]
Fertilizer a (ammonium sulfate)	2.33	3.00	4.02	5.69	6.85
Fertilizer b (40% SCU + 60 % urea)	2.30	3.02	[illegible]	[illegible]	[illegible]
Fertilizer c (Topdress + minors)	2.25	2.86	3.74	5.35	6.55
Statistical Significance[‡]					
signif. (sulfur)	ns	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-	-
CV % (sulfur)	15.4	21.1	21.1	22.1	18.4
signif. (fertilizer)	ns	ns	[illegible]	[illegible]	[illegible]
LSD (fertilizer)	-	-	-	-	-
CV % (fertilizer)	10.1	10.5	[illegible]	[illegible]	[illegible]
Trend Analysis (sulfur)[‡]					
linear	ns	ns	[illegible]	[illegible]	[illegible]
quadratic	ns	ns	ns	ns	ns

[‡]ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Table 5. Dutch Growers (1996 trial): Spruce growth index response to sulfur and fertilizer application (1997 – 1998)

Treatment	Growth Index[†] June, 1997	Nov., 1997	Oct., 1998	Oct., 1999	Sept., 2000
Sulfur A (0 kg S/ha)	4090	5120	[illegible]	[illegible]	[illegible]
Sulfur B (975 kg S/ha)	3920	4870	7940	12534	19366
Sulfur C (1950 kg S/ha)	3870	4730	[illegible]	[illegible]	[illegible]
Fertilizer a (ammonium sulfate)	3900	4730	7840	12601	19161
Fertilizer b (40% SCU + 60 % urea)	3950	50	[illegible]	[illegible]	[illegible]
Fertilizer c (Topdress + minors)	4000	4940	8130	13171	19951
Statistical Significance[‡]					
signif. (sulfur)	ns	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-	-
CV % (sulfur)	9.8	10.8	13.9	16.9	12.0
signif. (fertilizer)	ns	[illegible]	[illegible]	[illegible]	[illegible]
LSD (fertilizer)	-	-	-	-	-
CV % (fertilizer)	7.9	10	[illegible]	[illegible]	[illegible]
Trend Analysis (sulfur)[‡]					
linear	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
quadratic	ns	ns	ns	ns	ns

[†]growth index = height x average maximum width

[‡]ns; + or * = not significant; significant at $p \leq 0.10$ or 0.05, respectively

Table 6. Dutch Growers (1996 Trial): Fallgold Ash leaf dry weight response to the interaction effect of irrigation x sulfur treatment

Irrigation	Sulfur level	Leaf Dry Weight (g)
Overhead	A (0 kg S/ha)	[illegible]
	B (975 kg S/ha)	1.7
	C (1950 kg S/ha)	[illegible]
Drip	A (0 kg S/ha)	2.4
	B (975 kg S/ha)	[illegible]
	C (1950 kg S/ha)	2.4
LSD (0.05) [between sulfur levels at one irrigation level]		0.4

Table 7. Dutch Growers (1996 Trial): Fallgold Ash percent caliper change from June 1997 to November 1997 in response to irrigation scheme

Irrigation	Caliper change (%) (June 1997 - Nov. 1997)
Overhead	18.2
Drip	25.2
LSD (0.05)	2.5

1997 Trial (1997 – 2000)

Soil pH

Dutch Growers (site 1)

Sulfur was ineffective at significantly reducing soil pH in the first season. There was a highly significant ($p \leq 0.01$) linear decrease in soil pH in response to a linear increase in sulfur rates in October 1998. In June 1999, there was a significant ($p \leq 0.01$) quadratic trend with respect to pH response to increasing sulfur rates. This was a result of the soil pH being significantly ($p \geq 0.05$) higher in treatment B (975 kg S/ha) than in treatment C (1950 kg S/ha) and non-significantly higher than treatment A (0 kg S/ha). At the end of the 3rd growing season (October 1999) there was a significant ($p \geq 0.05$) increase in soil pH in response to increasing sulfur rates. In 2000 there were no significant differences or trends among sulfur treatments with respect to soil pH (Table 8a).

Fertilizer treatment 'a' (ammonium sulfate) significantly ($p \leq 0.01$) reduced soil pH more than either of the other two treatments in the first season. Fertilizer treatments 'b' (SCU + urea) and 'c'

(Topdress + Minors) were equivalent. There were no significant differences among fertilizer treatments in the second season through to the beginning of the fourth season (Table 8a).

Lakeshore (site 2)

Sulfur treatments had no effect on soil pH until the end of 1999 (3rd growing season) when there was a significant ($p \leq 0.01$) linear decrease in soil pH in response to increasing sulfur rates. In May 2000, there was a significant ($p \leq 0.05$) quadratic trend in soil pH in response to increasing sulfur rates. This was a result of a higher soil pH in the low sulfur rate (treatment B) than in either the control (treatment A) or the high sulfur rate (treatment C). At the end of 2000, this effect was no longer statistically significant (Table 9a).

Fertilizer treatment 'a' (ammonium sulfate) significantly ($p \leq 0.01$) reduced soil pH more than either of the other two treatments in the first season (Sept. 1997). Fertilizer treatments 'b' (SCU + urea) and 'c' (Topdress + Minors) were equivalent. There were no significant differences among fertilizer treatments in the second season. In June 1999, fertilizer treatment 'a' significantly reduced soil pH more than fertilizer treatment 'c'; fertilizer treatments 'a' and 'b' were equivalent as were treatments 'b' and 'c'. There were no differences among fertilizer treatments from October 1999 to September 2000 (Table 9a).

Caliper and Leaf Dry Weight

Dutch Growers (site 1)

Northwood maple: Sulfur treatments had a significant negative effect on leaf dry weight. Leaf dry weights in sulfur treatment C were significantly ($p \leq 0.05$) lower than those in sulfur treatments A and B. No other treatments or treatment interactions produced a significant effect (Table 10). Northwood maple was harvested in 1997 and has been removed from further analyses.

Mancana Ash: Neither sulfur nor fertilizer treatment produced a significant effect on leaf dry weight. There was a significant ($p \leq 0.05$) interaction between irrigation and sulfur affecting Mancana leaf dry weight. Under overhead irrigation, increasing levels of sulfur increased leaf

dry weight; under drip irrigation, increasing levels of sulfur reduced leaf dry weight (Table 11). Caliper was unaffected by any treatment (Table 12).

Advance Ash: Sulfur treatments had a significant effect on caliper at the end of the first growing season that was amplified by the end of the second season. The caliper of trees in the no sulfur treatment A was significantly ($p \leq 0.05$ and $p \leq 0.01$ at the end of the first and second seasons, respectively) higher than in treatments B and C; treatments B and C were equivalent. There were no differences among treatments in 1999. From 1997 to 1999, there was a significant ($p \leq 0.01$) linear decrease in caliper in response to a linear increase in sulfur rate. In 2000, there was only a slight ($p \leq 0.10$) linear decrease in caliper in response to the linear increase in sulfur rates (Table 8b).

Lakeshore (site 2)

Advance Columnar Ash: Neither sulfur nor fertilizer treatment produced a significant effect on leaf dry weight. There was a slightly significant ($p \leq 0.10$) linear reduction in caliper in response to a linear increase in sulfur rate in the second season (1998) and a more significant ($p \leq 0.05$) linear decrease in the last season (2000). There were no detectable trends in the first (1997) or third (1999) seasons (Table 9b).

Thunderchild Crab: Leaf dry weight was unaffected by fertilizer and sulfur treatments. There was a significant quadratic effect with respect to caliper in response to a linear increase in sulfur rates (i.e. the caliper of trees in treatment B was depressed compared to treatments A and C) at the end of the first ($p \leq 0.05$), second ($p \leq 0.01$) and third ($p \leq 0.05$) growing seasons. In September 2000, there was a significant ($p \leq 0.05$) linear reduction in caliper in response to the linear increase in sulfur rates (Table 13).

M121

IMPORTANT NOTE CONCERNING THE FOLLOWING PAGES

THE PAGES WHICH FOLLOW HAVE BEEN FILMED TWICE IN ORDER TO OBTAIN THE BEST REPRODUCTIVE QUALITY

USERS SHOULD CONSULT ALL THE PAGES REPRODUCED ON THE FICHE IN ORDER TO OBTAIN A COMPLETE READING OF THE TEXT.

REMARQUE IMPORTANTE CONCERNANT LES PAGES QUI SUIVENT

LES PAGES SUIVANTES ONT ÉTÉ REPRODUITES EN DOUBLE AFIN D'AMÉLIORER LA QUALITÉ DE REPRODUCTION

LES UTILISATEURS DOIVENT CONSULTER TOUTES LES PAGES REPRODUITES SUR LA FICHE AFIN D'OBTENIR LA LECTURE DU TEXTE INTÉGRAL

Micromedia
ProQuest

20 Victoria Street
Toronto, Ontario M5C 2N8
Tel.: (416) 362-5211
Toll Free: 1-800-387-2689
Fax: (416) 362-6161
Email: info@micromedia.on.ca

Table 8a. Dutch Growers (1997 trial): Advance Ash soil pH response to sulfur and fertilizer application (1997 – 2000)

Treatment	soil pH						
	Sept. 1997	May, 1998	Oct., 1998	June, 1999	Oct., 1999	May, 2000	Sept., 2000
Sulfur B (975 kg S/ha)	8.01	7.94	7.59	7.97	7.80	7.78	7.51
Fertilizer a (ammonium sulfate)	7.92	7.89	7.5	7.89	7.76	7.76	7.49
Fertilizer c (Topdress + minors)	8.04	7.93	7.59	7.91	7.78	7.80	7.50
signif. (sulfur)	ns	ns	ns	*	ns	ns	ns
CV % (sulfur)	3.9	2.0	1.2	0.9	1.5	1.5	1.3
LSD (fertilizer)	0.08	-	-	-	-	-	-
Trend Analysis (sulfur)[‡]							
quadratic	ns	ns	ns	**	ns	ns	ns

[‡]ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Table 8b. Dutch Growers (1997 trial): Advance Ash caliper response to sulfur and fertilizer application (1997 – 2000)

Treatment	Caliper (cm)			
	Nov., 1997	Oct., 1998	Oct., 1999	Sept. 2000
Sulfur B (975 kg S/ha)	1.83	3.01	4.53	5.39
Fertilizer a (ammonium sulfate)	1.85	3.14	4.65	5.41
Fertilizer c (Topdress + minors)	1.95	3.06	4.48	5.24
signif. (sulfur)	*	**	ns	ns
CV % (sulfur)	4.0	2.9	3.3	5.4
LSD (fertilizer)	-	-	-	-
Trend Analysis (sulfur)‡				
quadratic	ns	ns	ns	ns

‡ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Table 8a. Dutch Growers (1997 trial): Advance Ash soil pH response to sulfur and fertilizer application (1997 – 2000)

Treatment	soil pH						
	Sept. 1997	May, 1998	Oct., 1998	June, 1999	Oct., 1999	May, 2000	Sept., 2000
Sulfur A (0 kg S/ha)	7.97	7.92	7.62	7.91	7.41	7.79	7.46
Sulfur B (975 kg S/ha)	8.01	7.94	7.59	7.97	7.80	7.78	7.51
Sulfur C (1950 kg S/ha)	7.98	7.84	7.52	7.85	7.82	7.78	7.51
Fertilizer a (ammonium sulfate)	7.92	7.89	7.5	7.89	7.76	7.76	7.49
Fertilizer b (40% SCU + 60 % urea)	8.01	7.88	7.58	7.92	7.82	7.81	7.50
Fertilizer c (Topdress + minors)	8.04	7.93	7.59	7.91	7.78	7.80	7.50
Statistical Significance[†]							
signif. (sulfur)	ns	ns	ns	*	ns	ns	ns
LSD (sulfur)	-	-	-	0.09	-	-	-
CV % (sulfur)	3.9	2.0	1.2	0.9	1.5	1.5	1.3
signif. (fertilizer)	**	ns	ns	ns	ns	ns	ns
LSD (fertilizer)	0.08	-	-	-	-	-	-
CV % (fertilizer)	0.8	1.1	0.8	1.0	0.9	1.2	1.0
Trend Analysis (sulfur)[‡]							
linear	ns	+	**	*	*	ns	ns
quadratic	ns	ns	ns	**	ns	ns	ns

[†]ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Table 8b. Dutch Growers (1997 trial): Advance Ash caliper response to sulfur and fertilizer application (1997 – 2000)

Treatment	Caliper (cm)			
	Nov., 1997	Oct., 1998	Oct., 1999	Sept. 2000
Sulfur A (0 kg S/ha)	2.00	3.26	4.72	5.46
Sulfur B (975 kg S/ha)	1.83	3.01	4.53	5.39
Sulfur C (1950 kg S/ha)	1.93	3.06	4.52	5.28
Fertilizer a (ammonium sulfate)	1.85	3.14	4.65	5.41
Fertilizer b (40% SCU + 60 % urea)	1.86	3.14	4.64	5.48
Fertilizer c (Topdress + minors)	1.95	3.06	4.48	5.24
Statistical Significance[1]				
signif. (sulfur)	*	**	ns	ns
LSD (sulfur)	0.09	1.72	-	-
CV % (sulfur)	4.0	2.9	3.3	5.4
signif (fertilizer)	ns	ns	ns	ns
LSD (fertilizer)	-	-	-	-
CV % (fertilizer)	6.3	5.8	8.1	5.9
Trend Analysis (sulfur)[‡]				
linear	**	**	**	+
quadratic	ns	ns	ns	ns

[1]ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Table 9a. Lakeshore (1997 Trial): Advance Ash caliper and soil pH response to a one-time sulfur and fertilizer application (1997 – 2000)

Treatment	soil pH						
	Sept. 1997	May, 1998	Oct., 1998	June, 1999	Oct., 1999	May, 2000	Sept., 2000
Sulfur A (0 kg S/ha)	8.11	7.94	7.75	7.95	7.68	7.58	7.46
Sulfur B (975 kg S/ha)	8.15	7.96	7.70	7.89	7.68	7.63	7.44
Sulfur C (1950 kg S/ha)	8.05	7.93	7.74	7.89	7.65	7.54	7.44
Fertilizer a (ammonium sulfate)	8.03	7.93	7.71	7.88	7.65	7.59	7.45
Fertilizer b (40% SCU + 60 % urea)	8.13	7.93	7.73	7.91	7.69	7.58	7.45
Fertilizer c (Topdress + minors)	8.18	7.97	7.75	7.94	7.66	7.59	7.44
Statistical Significance[†]							
signif. (sulfur)	ns	ns	ns	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-	-	-	-
CV % (sulfur)	2.3	1.7	1.6	2.0	0.3	1.3	1.0
signif (fertilizer)	**	ns	ns	*	ns	ns	ns
LSD (fertilizer)	0.08	-	-	0.05	-	-	-
CV % (fertilizer)	0.8	1.2	0.9	0.7	1.0	1.3	1.0
Trend Analysis (sulfur)[‡]							
linear	ns	ns	ns	ns	**✓	ns	ns
quadratic	ns	ns	ns	ns	**	*	ns

[†]ns; + or ** = not significant; significant at $p \leq 0.10$ or 0.01, respectively. The check mark (✓) indicates the most significant trend (by calculated F-value) when significance levels appear the same.

Table 9b. Lakeshoré (1997 Trial): Advance Ash caliper response to a one-time sulfur and fertilizer application (1997 – 2000)

Treatment	Caliper (cm)			
	Nov., 1997	Oct., 1998	Oct., 1999	Sept., 2000
Sulfur A (0 kg S/ha)	2.21	2.96	4.15	5.11
Sulfur B (975 kg S/ha)	2.14	2.83	3.92	5.01
Sulfur C (1950 kg S/ha)	2.20	2.84	3.98	4.81
Fertilizer a (ammonium sulfate)	2.19	2.87	9.96	4.84
Fertilizer b (40% SCU + 60 % urea)	2.21	2.90	4.08	5.09
Fertilizer c (Topdress + minors)	2.15	2.86	4.01	4.99
Statistical Significance[‡]				
signif. (sulfur)	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-
CV % (sulfur)	6.7	8.9	11.6	9.1
signif (fertilizer)	ns	ns	ns	ns
LSD (fertilizer)	-	-	-	-
CV % (fertilizer)	3.1	7.5	8.0	9.3
Trend Analysis (sulfur)[‡]				
linear	ns	+	ns	*
quadratic	+	ns	ns	ns

[‡]ns, + or * = not significant; significant at $p \leq 0.10$ or 0.01, respectively.

Table 10. Dutch Growers (1997 trial): Sulfur effects on the leaf dry weight of Northwood maple weight (Aug. 25, 1997)

Sulfur level	leaf dry weight (g)
A (0 kg S/ha)	6.0
B (975 kg S/ha)	5.1
C (1950 kg S/ha)	4.8
LSD (0.05)	1.0

Table 11. Dutch Growers (1997 trial): Irrigation x sulfur level effects on Mancana leaf dry weight (Aug. 25, 1997)

Irrigation	sulfur level	leaf dry weight (g)
overhead	A (0 kg S/ha)	14.0
	B (975 kg S/ha)	14.1
	C (1950 kg S/ha)	16.5
drip	A (0 kg S/ha)	10.6
	B (975 kg S/ha)	10.9
	C (1950 kg S/ha)	9.0
LSD (0.05) [between sulfur levels in the same irrigation treatment]		2.3

Table 9a. Lakeshore (1997 Trial): Advance Ash caliper and soil pH response to a one-time sulfur and fertilizer application (1997 – 2000)

Treatment	soil pH						
	Sept. 1997	May, 1998	Oct., 1998	June, 1999	Oct., 1999	May, 2000	Sept., 2000
Sulfur A (488 kg S/ha)	8.11	7.94	7.75	7.95	7.68	7.58	7.46
Sulfur B (975 kg S/ha)	8.15	7.96	7.70	7.89	7.68	7.63	7.44
Fertilizer a (ammonium sulfate)	8.03	7.93	7.71	7.88	7.65	7.59	7.45
Fertilizer c (Topdress + minors)	8.18	7.97	7.75	7.94	7.66	7.59	7.44
signif. (sulfur)	ns	ns	ns	ns	ns	ns	ns
CV % (sulfur)	2.3	1.7	1.6	2.0	0.3	1.3	1.0
signif. (fertilizer)	ns	ns	ns	ns	ns	ns	ns
LSD (fertilizer)	0.08	-	-	0.05	-	-	-
CV % (fertilizer)	0.8	1.2	0.9	0.7	1.0	1.0	1.0
Trend Analysis (sulfur)[‡]							
linear	ns	ns	ns	ns	✓	ns	ns
quadratic	ns	ns	ns	ns	**	*	ns

[‡]ns, + or ** = not significant; significant at $p \leq 0.10$ or 0.01, respectively. The check mark (✓) indicates the most significant trend (by calculated F-value) when significance levels appear the same.

Table 9b. Lakeshore (1997 Trial): Advance Ash caliper response to a one-time sulfur and fertilizer application (1997 – 2000)

Treatment	Caliper (cm) Nov., 1997	Oct., 1998	Oct., 1999	Sept., 2000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sulfur B (975 kg S/ha)	2.14	2.83	3.92	5.01
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fertilizer a (ammonium sulfate)	2.19	2.87	9.96	4.84
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fertilizer c (Topdress + minors)	2.15	2.86	4.01	4.99
[illegible]				
signif. (sulfur)	ns	ns	ns	ns
[illegible]				
CV % (sulfur)	6.7	8.9	11.6	9.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD (fertilizer)	-	-	-	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trend Analysis (sulfur) ‡				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
quadratic	+	ns	ns	ns

‡ns; + or ** = not significant; significant at $p \leq 0.10$ or 0.01, respectively.

Table 10. Dutch Growers (1997 trial): Sulfur effects on the leaf dry weight of Northwood maple weight (Aug. 25, 1997)

Sulfur level	leaf dry weight (g)
A (0 kg S/ha)	5.0
B (975 kg S/ha)	5.1
C (1950 kg S/ha)	4.8
LSD (0.05)	1.0

Table 11. Dutch Growers (1997 trial): Irrigation x sulfur level effects on Mancana leaf dry weight (Aug. 25, 1997)

Irrigation	sulfur level	leaf dry weight (g)
overhead	A (0 kg S/ha)	[illegible]
	B (975 kg S/ha)	14.1
[illegible]	[illegible]	[illegible]
drip	A (0 kg S/ha)	10.6
[illegible]	[illegible]	[illegible]
	C (1950 kg S/ha)	9.0
LSD (0.05) [between sulfur levels in the same irrigation treatment]		2.3

Table 12. Dutch Growers (1997 trial): Mancana ash caliper response to sulfur and fertilizer application (1997 – 2000)

Treatment	Caliper (cm) Nov., 1997	Oct., 1998	Oct., 1999	Sept. 2000
Sulfur A (0 kg S/ha)	2.33	3.04	4.23	5.33
Sulfur B (975 kg S/ha)	2.30	2.99	4.13	5.31
Sulfur C (1950 kg S/ha)	2.32	2.95	4.17	5.20
Fertilizer a (ammonium sulfate)	2.33	3.08	4.27	5.35
Fertilizer b (40% SCU + 60 % urea)	2.34	2.98	4.17	5.22
Fertilizer c (Topdress + minors)	2.28	2.93	4.10	5.27
Statistical Significance[‡]				
signif. (sulfur)	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-
CV % (sulfur)	9.3	8.2	8.3	9.0
signif (fertilizer)	ns	ns	ns	ns
LSD (fertilizer)	-	-	-	-
CV % (fertilizer)	6.0	6.1	5.9	7.3
Trend Analysis (sulfur)[‡]				
linear	ns	ns	ns	ns
quadratic	ns	ns	ns	ns

[‡]ns; + or * = not significant; significant at $p \leq 0.10$ or 0.05, respectively

Table 13. Lakeshore (1997 trial): Thunderchild caliper response to sulfur and fertilizer application (1997 – 1998)

Treatment	Caliper (cm) Nov. 1997	Oct. 1998	Oct., 1999	Sept., 2000
Sulfur 0 (0 kg S/ha)	2.07	2.64	3.51	4.25
Sulfur 1 (975 kg S/ha)	2.01	2.40	3.23	3.96
Sulfur 2 (1950 kg S/ha)	2.04	2.65	3.39	3.96
Fertilizer 1 (ammonium sulfate)	2.05	2.64	3.48	4.16
Fertilizer 2 (40% SCU + 60 % urea)	2.04	2.50	3.32	3.99
Fertilizer 3 (Topdress + minors)	2.03	2.56	3.33	4.02
Statistical Significance[‡]				
signif. (sulfur)	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-
CV % (sulfur)	3.1	10.4	9.9	12.0
signif (fertilizer)	ns	ns	ns	ns
LSD (fertilizer)	-	-	-	-
CV % (fertilizer)	3.9	7.1	7.1	9.2
Trend Analysis (sulfur)[‡]				
linear	ns	ns	ns	*
quadratic	*	**	*	ns

[‡]ns; * or** = not significant; significant at $p \leq 0.05$ or 0.01, respectively

Table 12. Dutch Growers (1997 trial): Mancana ash caliper response to sulfur and fertilizer application (1997 – 2000)

Treatment	Caliper (cm) Nov., 1997	Oct., 1998	Oct., 1999	Sept. 2000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sulfur B (975 kg S/ha)	2.30	2.99	4.13	5.31
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fertilizer a (ammonium sulfate)	2.33	3.08	4.27	5.35
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fertilizer c (Topdress + minors)	2.28	2.93	4.10	5.27
[illegible]				
signif. (sulfur)	ns	ns	ns	ns
[illegible]				
CV % (sulfur)	9.3	8.2	8.3	9.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD (fertilizer)	-	-	-	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trend Analysis (sulfur) ‡				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
quadratic	ns	ns	ns	ns

‡ns; + or * = not significant; significant at $p \leq 0.10$ or 0.05, respectively

Table 13. Lakeshore (1997 trial): Thunderchild caliper response to sulfur and fertilizer application (1997 – 1998)

Treatment	Caliper (cm) Nov. 1997	Oct. 1998	Oct., 1999	Sept., 2000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sulfur 1 (975 kg S/ha)	2.01	2.40	3.23	3.96
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fertilizer 1 (ammonium sulfate)	2.05	2.64	3.48	4.16
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fertilizer 3 (Topdress + minors)	2.03	2.56	3.33	4.02
[illegible]				
signif. (sulfur)	ns	ns	ns	ns
[illegible]				
CV % (sulfur)	3.1	10.4	9.9	12.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LSD (fertilizer)	-	-	-	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trend Analysis (sulfur) ‡				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
quadratic	*	**	*	ns

‡ns; * or** = not significant; significant at $p \leq 0.05$ or 0.01, respectively

Discussion

Soil pH effects

Sulfur applied at close to two tonnes per hectare can significantly reduce soil pH (Owen *et al.* 1999, Beverly 1987, Bole 1986, Mahler 1986, Nnadi and Abed 1983); however, this reduction requires at least one full growing season before the effect is noticeable (Messenger and Nesbit 1998, Kidder *et al.* 1990). Soil pH response to sulfur application was variable and consisted of one of three responses: linear decrease, quadratic trend (i.e. low sulfur rate resulted in a higher pH than either control or high sulfur rate) or no significant response.

The first case, a linear decrease in soil pH in response to a linear increase in sulfur rates, was expected. The more elemental sulfur that is available for conversion to sulfate via biological oxidation, the more pronounced the pH reduction (Slaton *et al.* 1997, Beverly 1986, Mahler 1986).

The second case is somewhat difficult to explain. Sulfur, once oxidized to sulfate ions, is highly mobile in the soil solution and is prone to leaching (Zhao *et al.* 1996, Boswell et al. 1995/1996, Germida and Janzen 1993, Kidder et al. 1990, Janzen and Bettany 1987). This helps explain why sulfur treatments may not be long acting but does not explain why soil pH rises. The rise in pH could be partly due to the action of the acid (hydrogen sulfate) on basic substances other than those in the exchange complex (Bole 1986, Fraps and Fudge 1936). Furthermore, biological oxidation of minerals also leads to immobilization of those same elements that are oxidized, making them unavailable to the soil solution. In this case, sulfate ions are not available to reduce pH. In the high sulfur rate treatment there may still be elemental sulfur left to oxidize and therefore continues to have an effect on soil pH. Also, sulfur is not permanently immobilized and will be released to the soil solution over time as the microbes die and decompose.

The third case, lack of significant results near the end of the study is a reflection of the high capacity of Saskatchewan soil microbes to oxidize sulfur to sulfate which is subsequently easily leached away (Janzen and Bettany 1987). In one study (Janzen 1990), over 50% of the sulfur

applied to a Chernozem soil (loam) oxidized within 60 days. In a study conducted in Alberta (Bole 1986), the pH reducing affect of applying 3.3 t sulfur/ha persisted only 4 years.

The decrease in soil pH was not as high as expected, as some reported reductions of 1 pH unit or more using the same or lower rates of sulfur as we did (Mahler, 1986). However, sulfur particle size, soil characteristics (i.e. buffering characteristics), temperature, moisture, sulfur immobilization and native populations of sulfur oxidizing micro-organisms all play a role in the degree of acidification by sulfur (Zhao et al. 1996, Watkinson and Lee 1994, Germida and Janzen 1993, Beverly and Anderson 1987, Janzen and Bettany 1987). Beverly (1986) demonstrated that elemental sulfur reduced soil pH by only 20% of its theoretical ability in the first season. The discrepancy that he found was attributed to immobilization, neutralization by bicarbonates and incomplete oxidation. Nielsen *et al.* (1993) found similar effects and concluded that soil response to sulfur application was a function of initial $CaCO_3$ content and soil texture.

In addition to differences among treatments, there were also differences between sites. These differences is sulfur mediated soil pH reduction can be attributed to differences in soil characteristics (e.g. buffering capacity, initial carbonate levels), irrigation water source, water pH & alkalinity, and management practices (Slaton *et al.* 1997, Boswell *et al.* 1995/1996, Zhao *et al.* 1996, Germida and Janzen 1993, Neilsen *et al.* 1993, Ali and Stroehlein 1991, Bole 1986, Chapman 1936).

Short-term soil pH reduction is possible by applying acidifying fertilizers (AF's) such as ammonium sulfate (Messenger and Nesbit 1998, Barak *et al.* 1997, Lockhart and Sanchez 1989, Beverly and Anderson 1987). This effect is only evident in the year of application and so continued use of AF's is required in highly buffered alkaline soils in the absence of other acidifying agents. This was demonstrated at Lakeshore where there was no residual effect in 1997 from fertilizer applied in 1996 (1996 trial) (cp. significant reduction in soil pH from ammonium sulfate in one season compared to the other two nitrogen sources).

One reason why fertilizer treatments 'b' and 'c' were ineffective at reducing soil pH in the season of application is that the main acidifying component in both of these fertilizers is sulfur. From the above discussion for elemental sulfur effects, we know that significant pH adjustment due to sulfur application will not occur in the year of application. Also, the amount of sulfur applied with the fertilizer is very small and will only contribute marginally to pH reduction. This perhaps explains why in May, 1997 at Dutch Growers, fertilizer treatment 'c' in the 1996 trial was significantly more effective at reducing soil pH than either fertilizer treatments 'a' and 'b'. Topdress + Minors (treatment 'c') has almost equal amounts of sulfur and nitrogen (17-3-6-16) and after one year, the sulfur likely contributed to the lower soil pH of this treatment. By the fall, though, ammonium sulfate (treatment 'a') was superior to the other fertilizer treatments in reducing soil pH. These results match those of other trials where ammonium sulfate was found to be consistently superior to other AF's in reducing soil pH quickly and effectively (Messenger and Nesbit 1998, Barak *et al.* 1997, Lockhart and Sanchez 1989, Beverly and Anderson 1987). In 1998 - 2000, fertilizer treatments in both the 1996 and 1997 trials were ineffective in reducing soil pH. This could be a result of the overriding effect that sulfur treatment has on soil pH, thereby masking any reduction caused by fertilizer (Germida and Janzen 1993).

Other effects

There was a linear decrease in the spruce growth index coincident to the linear decrease in soil pH and both can be attributed to increasing levels of sulfur. Furthermore, leaf samples evaluated in 1997 showed a similar reduction in response to increasing sulfur levels. These results were not expected, as it was thought that with reducing soil pH, plant growth would benefit due to increasing nutrient availability (Slaton et al. 1998, Michail *et al.* 1996, Chapman 1936). This phenomenon has been reported in other trials (Cline and Silvernail 1997, Mahler 1986) and a number of hypotheses have been forwarded to explain the decrease in growth in response to soil acidification. The most common explanation of decreased growth is that soil acidification increases aluminium and/or magnesium ion concentration (Messenger and Nesbit 1998, Bruce and Wylie 1997, Hallett and Hornbeck 1997, Berglund 1996, Cline and Kaul 1990, Hodge and Lewis 1989, Timmer 1985). The aluminium and/or magnesium concentrations may directly affect plant growth via plant toxicity response (Berglund 1996, Hodge and Lewis 1989, Timmer

1985). In our trials, pH did not drop low enough to lead to toxic aluminium ion concentration levels. The more likely explanation is that essential nutrients were unavailable. This could occur with aluminium competing for nutrient absorption sites on the root surface (Cline and Silvernail 1997, Sverdrup *et al.* 1994) leading to nutrient imbalances within the plant (Cline and Silvernail 1997, Rehab *et al.* 1979). Alternatively, it has been shown that nitrogen is immobilized following a sulfur application (Germida and Janzen 1993, Nyborg and Mahli 1991). Janzen and Bettany (1987) determined that there is substantial microbial oxidation of elemental sulfur in Saskatchewan; this would lead to a reduction of available nitrogen, as the microbial populations would use it as a convenient energy and food source. Finally, with increased acidity comes increased nutrient solubility and some nutrients may have been in short supply through leaching (Suarez and Jones, 1982).

The sulfur levels used were ones recommended in the literature; however, the recommendations were generated from reports aimed at correcting leaf chlorosis problems and not at maximizing growth (Whitcomb 1986, Messenger 1984). It is reasonable to assume that soil pH reduction will have a positive effect on nutrient availability but if sulfur is the main acidification agent, rates will have to be much lower than those used in our trials to avoid deleterious effects. Since other trials (Messenger and Nesbit 1998, Barak *et al.* 1997, Lockhart and Sanchez 1989, Beverly and Anderson 1987) and ours have demonstrated that ammonium sulfate is an effective acidification agent, it may be more appropriate to use this product as both the main nitrogen source and as an acidulant.

Irrigation system had no effect on soil pH (data not shown); however there was a significant effect on caliper change in Fallgold ash (1996 trial) in 1997 where drip irrigation was superior to overhead irrigation. Trees under drip were irrigated more frequently than those under overhead irrigation, resulting in more even soil moisture and thus promoting better growth. This should not be taken as conclusive proof that drip irrigation is superior to overhead irrigation; rather that soil moisture status must be maintained at acceptable levels throughout the growing season, especially for newly planted bare root stock.

Conclusions

Soil pH can rise over time due to irrigation water quality (from the observational data; Table 2) and so efforts to reduce this effect are necessary. Soil pH can be adjusted by using elemental sulfur but the changes occur slowly and are not apparent until after one full season. Acidifying fertilizers can also effectively and rapidly reduce soil pH but the effect is short-lived lasting only one season.

Sulfur rates used in these trials, unfortunately had deleterious effects on growth; therefore we cannot provide clear recommendations with respect to soil pH reduction strategies using sulfur. What we can say with certainty is that with continued use of high alkaline irrigation water, soil pH will rise and that nutrient availability will decrease. Until safe and effective rates of sulfur are determined, acidifying fertilizers (Table 1), in particular ammonium sulfate, should be used as the primary pH reduction agents. Furthermore growers should develop an overall soil alkalinity management scheme by reducing the total amount of irrigation water by converting from overhead irrigation to drip (i.e. treating the cause), treating irrigation water to reduce alkalinity (i.e. treating the cause) or some combination of strategies of irrigation management and soil treatment (i.e. treating the symptom).

Experiment 2. Soil pH adjustment using only elemental sulfur

To remove the possible confounding effects of acidifying fertilizers, a small trial was set up May, 1997 to test the effect of applying only sulfur to adjust soil pH.

Materials and Methods

Site

DG = Dutch Growers

Treatment

Sulfur [Tiger 0-0-0-90] application (one time broadcast application at planting, May 1997)

A) 0 kg S/ha (0 lb. S/ac)

B) 975 kg S/ha (870 lb. S/ac)

C) 1950 kg S/ha (1740 lb. S/ac)

Species

Bergeson Ash; *Fraxinus* x 'Bergeson'

Measurements

Soil was sampled to a depth of 15 cm on September 23 1997, May 5 1998, October 1 1998, October 14 1999 and September 1 2000. Soil pH was determined by mixing 50 g of soil with 100- ml distilled water, allowed to sit for 5 minutes followed by stirring while measuring pH using an electronic pH meter (Orion, model 451). Caliper was measured 30 cm above ground level on June 25 1997, November 4 1997, October 8 1998, October 14 1999, and September 2000. Leaf samples (10 from each tree) were collected on August 22, 1997 and were weighed after drying.

Experimental Design

Treatments were arranged in a Randomized Complete Block Design (RCBD). Treatments were replicated five times with three trees per treatment. Sulfur was broadcast within row only and was not incorporated. Growth data was tested using GLM and initial measurements were used as

a covariate to account for variation in planting stock. Soil pH data was tested using ANOVA without covariate analysis. Treatment means were compared using least significant difference (LSD) whenever the F-tests for treatments were significant at $p \leq 0.05$. Trend analysis with respect to caliper and soil pH was performed to test for linear or other relationships in response to a linear increase in sulfur rates.

Results

Soil pH

There was no significant difference among treatments nor was there a significant linear reduction in soil pH with increasing amounts of applied sulfur at the end of the first season. At the beginning of the second season there was a significant ($p \leq 0.05$) quadratic response (i.e. soil pH in treatment group B was higher than in groups A or C). By the second season, there was a significant ($p \leq 0.01$) linear reduction in soil pH in response to a linear increase in sulfur rate. In 1999, there was no significant treatment response. There was a slight ($p \leq 0.10$) linear decrease in soil pH in response to increasing sulfur rates in May 2000. There were no significant effects in September 2000 (Table 14a).

Caliper and Leaf Dry Weight

There was no significant difference among treatments for leaf dry weight (data not shown). At the end of the second season (1998), there was a significant ($p \leq 0.05$) quadratic response with respect to caliper in response to sulfur treatments (i.e. caliper in treatment group B was higher than in groups A or C). Otherwise, there was no significant treatment response (Table 14b).

Discussion & Conclusions

The pH reduction in response to sulfur rates was similar to the other trials. What was different was the caliper response. This response is somewhat difficult to explain. The quadratic response in caliper in October 1998 matched the response in soil pH in May 1998. While this may be coincidental, it is suggestive that the most important time of growth is in the spring. At the beginning of the year, only a relatively small amount of sulfur had been converted to sulfate and in Treatment B, this amount did not have a deleterious affect on plant growth nor a reducing

affect on soil pH. However, in 1999 there were no significant treatment differences or trends with respect to soil pH or caliper development. This may be related to the high rain levels at the beginning of the year, supplying sufficient soil moisture to maintain maximum growth. The high rain levels may also have leached any sulfate ions thus reducing their acidifying effect on soil pH (Zhao *et al.* 1996, Boswell *et al.* 1995/1996, Germida and Janzen 1993, Kidder *et al.* 1990). The cool growing temperatures would also have limited the conversion of sulfur to sulfate ions by both bacterial and chemical action (Zhao *et al.* 1996, Watkinson and Lee 1994, Germida and Janzen 1993). The slight decrease in soil pH in May 2000 may be a result of further conversion of sulfur to sulfate or remobilization of immobilized sulfur, however the significance level is too low to be relied on as an accurate reflection of the situation. At the last sampling (September 2000), there were no significant trends.

As before, we cannot give any clear recommendations in regards to the use of sulfur in reducing soil pH. We can only suggest that soil pH can be reduced by a) using acidifying fertilizers (i.e. treating the symptom), b) reducing the total amount of irrigation water by only supplying enough water to bring soil moisture levels to field capacity, c) converting from overhead irrigation to drip (i.e. treating the cause), d) treating irrigation water to reduce alkalinity (i.e. treating the cause) or e) some combination of strategies.

M121

IMPORTANT NOTE CONCERNING THE FOLLOWING PAGES

THE PAGES WHICH FOLLOW HAVE BEEN FILMED TWICE IN ORDER TO OBTAIN THE BEST REPRODUCTIVE QUALITY

USERS SHOULD CONSULT ALL THE PAGES REPRODUCED ON THE FICHE IN ORDER TO OBTAIN A COMPLETE READING OF THE TEXT.

REMARQUE IMPORTANTE CONCERNANT LES PAGES QUI SUIVENT

LES PAGES SUIVANTES ONT ÉTÉ REPRODUITES EN DOUBLE AFIN D'AMÉLIORER LA QUALITÉ DE REPRODUCTION

LES UTILISATEURS DOIVENT CONSULTER TOUTES LES PAGES REPRODUITES SUR LA FICHE AFIN D'OBTENIR LA LECTURE DU TEXTE INTÉGRAL

Micromedia
ProQuest

20 Victoria Street
Toronto, Ontario M5C 2N8
Tel.: (416) 362-5211
Toll Free: 1-800-387-2689
Fax: (416) 362-6161
Email: info@micromedia.on.ca

Table 14a. Dutch Growers (Sulfur only 1997 trial): Bergeson Ash soil pH response to sulfur application (1997 – 2000)

Treatment	soil pH						
	Sept. 1997	May, 1998	Oct., 1998	June, 1999	Oct., 1999	May, 2000	Sept., 2000
[illegible]	[illegible]	8.02	7.86	8.01	7.90	7.88	7.69
Sulfur B (975 kg S/ha)	8.21	8.07	7.75	7.99	7.89	7.88	7.64
[illegible]	[illegible]	[illegible]	7.67	7.93	7.76	7.79	7.60
Statistical Significance‡							
[illegible]	ns	ns	ns	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-	-	-	9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Trend Analysis (sulfur)‡							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
quadratic	ns	*	ns	ns	ns	ns	ns

‡ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Table 14b. Dutch Growers (Sulfur only 1997 trial): Bergeson Ash caliper response to sulfur application (1997 – 2000)

Treatment	Caliper (cm)			
	Nov., 1997	Oct., 1998	Oct., 1999	Sept., 2000
[illegible]	2.04	3.16	4.71	5.98
Sulfur B (975 kg S/ha)	2.05	3.34	5.09	6.07
[illegible]	[illegible]	3.10	4.74	5.91
Statistical Significance‡				
[illegible]	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-
[illegible]	8.7	7.8	9.0	6.5
Trend Analysis (sulfur)‡				
[illegible]	ns	ns	ns	ns
quadratic	ns	*	ns	ns

‡ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Table 14a. Dutch Growers (Sulfur only 1997 trial): Bergeson Ash soil pH response to sulfur application (1997 – 2000)

Treatment	soil pH						
	Sept. 1997	May, 1998	Oct., 1998	June, 1999	Oct., 1999	May, 2000	Sept., 2000
Sulfur A (0 kg S/ha)	8.27	8.02	7.86	8.01	7.90	7.88	7.69
Sulfur B (975 kg S/ha)	8.21	8.07	7.75	7.99	7.89	7.88	7.64
Sulfur C (1950 kg S/ha)	8.12	7.97	7.67	7.93	7.76	7.70	7.60
Statistical Significance‡							
signif. (sulfur)	ns	ns	ns	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-	-	-	9
CV % (sulfur)	1.7	1.6	2.3	2.2	2.7	1.9	2.1
Trend Analysis (sulfur) ‡							
linear	ns	ns	**	ns	ns	+	ns
quadratic	ns	*	ns	ns	ns	ns	ns

‡ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Table 14b. Dutch Growers (Sulfur only 1997 trial): Bergeson Ash caliper response to sulfur application (1997 – 2000)

Treatment	Caliper (cm)			
	Nov., 1997	Oct., 1998	Oct., 1999	Sept., 2000
Sulfur A (0 kg S/ha)	2.04	3.16	4.71	5.98
Sulfur B (975 kg S/ha)	2.05	3.34	5.09	6.07
Sulfur C (1950 kg S/ha)	1.99	3.10	4.74	5.91
Statistical Significance‡				
signif. (sulfur)	ns	ns	ns	ns
LSD (sulfur)	-	-	-	-
CV % (sulfur)	8.7	7.8	9.0	6.5
Trend Analysis (sulfur) ‡				
linear	ns	ns	ns	ns
quadratic	ns	*	ns	ns

‡ns; +, * or ** = not significant; significant at $p \leq 0.10, 0.05$ or 0.01, respectively

Bibliography

Ali, A-M.S. and J.L. Stroehlein. 1991. Reactions of urea phosphate in calcareous and alkaline soils: II. Effects on soil sodium and salinity. Commun. in Soil Sci. Plant Anal. 22(11&12): 1257 – 1268.

Barak, P., B.O. Jobe, A.R. Krueger, L.A. Peterson and D.A. Laird. 1997. Effects of long-term soil acidification due to nitrogen fertilizer inputs in Wisconsin. Plant and Soil 197: 61 – 69.

Berglund, K. 1996. Agricultural improvement of cultivated organic soils I. Effects of deep cultivation, liming, irrigation and P-fertilization on crop yields. Soil Use and Management. 12: 169 – 175.

Beverly, R.B. 1986. Celery response to foliar nutritional sprays and acidification of a histosol. HortScience 22(6): 1271 – 1273.

Beverly, R.B. and D.L. Anderson. 1987. Effects of acid source on soil pH. Soil Sci. 143(4): 301 – 303.

Bole, J.B. 1986. Amelioration of a calcareous solonetzic soil by irrigation, deep ripping, and acidification with elemental sulfur. Can. J. Soil Sci. 66: 347 – 356.

Boswell, C.C., B. Swanney and A.C. Braithwaite. 1995/1996. The effects of different manufacturing techniques on the availability of sulfate to pasture from mixtures of elemental sulfur with either triple superphosphate or partially acidulated reactive phosphate rock. Fert. Res. 44(3): 255 – 263.

Bruce, R.C., A.L. Clarke (ed.) and P.B. Wylie. 1997. Soil acidification. *in* Sustainable crop production in the sub tropics: an Australian perspective. Queensland Dept. of Primary Industries, Information Centre, Brisbane, Australia, pp. 97 – 111.

Chapman, H.D. 1936. Effect of nitrogenous fertilizers, organic matter, sulfur and colloidal silica on the availability of phosphorus in calcareous soils. J. Amer. Soc. Agron. 28(2): 135 – 145.

Cline, G.R. and A.F. Silvernail. 1997. Effects of soil acidity on the growth of *Sericea Lespedeza*. J. Plant Nutr. 20(12): 1657 – 1666.

Cline, G.R. and K. Kaul. 1990. Inhibitory effect of acidified soil on the soybean/*Bradyrhizobium* symbiosis. Plant and Soil 127: 243 – 249.

Cowling, W.A. and J.C. Clements. 1993. Association between collection site soil pH and chlorosis in *Lupinus angustifolius* induced by a fine-texture, alkaline soil. Aust. J. Agric. Res. 44: 1821 – 1836.

Fraps, G.S. and J.F. Fudge. 1936. The effect of sulfur and sulfuric acid upon the development of soil acidity at different depths. J. Amer. Soc. Agron. 28(12): 1012 – 1016.

Germida, J.J. and H.H. Janzen. 1993. Factors affecting the oxidation of elemental sulfur in soils. Fert. Res. 35(1&2): 101 – 114.

Hallett, R.A. and J.W. Hornbeck. 1997. Foliar and soil nutrient relationships in red oak and white pine forests. Can. J. For. Res. 27: 1233 – 1244.

Hodge, T.J.V. and D.C. Lewis. 1989. A description of acid soils and the relationships between properties of acid soils and the nutrient status of grazed pastures in the south-east of south Australia. Aust. J. Soil. Res. 27: 149 – 159.

Janzen, H.H. 1990. Elemental sulfur oxidation as influenced by plant grwoth and degree of dispersion within soil. Can. J. Soil Sci. 70: 499 – 502.

Janzen, H.H. and J.R. Bettany. 1987. Oxidation of elemental sulfur under field conditions in central Saskatchewan. Can. J. of Soil Sci. 67: 609 – 618.

Kidder, G., M.J. Holsinger, and T.H. Yeager. 1990. Lowering of calcareous soil pH in field-grow containers. J. Environ. Hort. 8(1): 1 – 4.

Lockhart, J.M. and C.A. Sanchez. 1989. Acidification of an Everglades histosol using several fertilizer sources. Proc. Fl. State Hort. Soc. 102: 344-345.

Mahler, R.L. 1986. Evaluation of soil pH manipulation on crop production in northern Idaho. Commun. Soil Sci. Plant Anal. 17(9): 905 – 919.

Messenger, A.S. and J.L. Nesbit. 1998. Effects of soil acidification on growth and nutrition of white oak seedlings. Commun. Soil Sci. Plant Anal. 29(7&8): 793 – 807.

Messenger, Steve. 1984. Treatment of chlorotic oaks and red maples by soil acidification. Journal of Arboriculture, 10: 122-128.

Michail, N.N., F.S. Faris, M.W.A. Hassan and R.G. Kerlous. 1996. Improvement of leguminous vegetables production in calcareous soil by addition of some acidifying materials. I. Effects of yield and yield components. Fert. Env. 43(1-3): 87-91.

Neilsen, D., E.J. Hogue, P.B. Hoyt, and B.G. Drought. 1993. Oxidation of elemental sulphur and acidulation of calcareous orchard soils in southern British Columbia. Can. J. Soil Sci. 73: 103 – 114.

Nnadi, L.A. and S.M. Abed. 1983. Evaluation of sulphur-coated urea fertilizers in savannah soils. 2. Effects on soil pH and residual nitrogen. J. Agric. Sci. 101(1): 125 – 129.

Nyborg, M. and S.S. Mahli. 1991. Acidification of forest soil by elemental sulphur dust. Dev. Plant Soil Sci. 45: 555 – 563.

Owen, K.M., R.H. Marrs, C.S.R. Snow and C.E. Evans. 1999. Soil acidification – the use of sulphur and acidic plant material to acidify arable soils for the recreation of heathland and acidic grassland at Minsmere, UK. Biol. Conserv. 87: 105 – 121.

Rehab, F.I., A. Wallace and E.M. Romney. 1979. Effect of acidification of a calcareous soil on yield and mineral composition of three cultivars of cotton grown in a glasshouse. Alexandria J. Agric. Res. 27(1): 247 – 249.

Remon, James, Toby Goodale, Jim Ward and Carl E. Whitcomb. 1977. Effects of sulfur on reducing the pH of an alkaline soil. Oklahoma Agricultural Experimental Station Research Report, 760: 18-20.

Slaton, N.A., R.J. Norman, S. Ntamatungiro and C.E. Wilson Jr. 1997. Amendment of alkaline soils with elemental sulfur. Res. Ser. AR. Agric. Exp. Station (456): 130 – 136.

Slaton, N.A., S. Ntamatungiro, C.E. Wilson Jr. and R.J. Norman. 1998. Influence of two elemental sulfur products applied to an alkaline silt loam on rice growth. Res. Ser. AR Ag. Exp. Station. (460): 326 – 329.

Suarez, E.L. and U.S. Jones. 1982. Division S-4 – Soil fertility and plant nutrition. Soil Sci. Soc. Am. J. 46: 976 – 980.

Sverdrup, H., P. Warfvinge and B. Nilhgård. 1994. Assessment of soil acidification effects on forest growth in Sweden. Water, Air and Soil Pollution 78: 1 – 36.

Timmer, V.R. 1985. Response of a hybrid poplar clone to soil acidification and liming. Can. J. Soil Sci. 65: 727 – 735.

Watkinson, J.H. and A. Lee. 1994. Kinetics of field oxidation of elemental sulfur in New Zealand pastoral soil s and the effects of soil temperature and moisture. Fert. Res. 37(1): 59 – 68.

Whitcomb, Carl E. 1986. Solving the iron chlorosis problem. Journal of Arboriculture, 12: 44-48.

Whitcomb, Carl E. 1987. Solving the iron chlorosis problem. Ch 28 in Establishment and maintenance of landscape plants. Lacebark publications, Stillwater Oklahoma, pp. 497 – 514.

Zhao, F.J., S.Y. Loke. A.R. Crosland and S.P. McGrath. 1996. Method to determine elemental sulphur in soils applied to measure sulfur oxidation

The Nursery Production Literature Collection (NPLC)

The Nursery Production Literature Collection (NPLC) is a collection of articles and selected book chapters covering a number of topics related to nursery production and relevant research techniques. This collection has been gathered over the past 5 years and contains nearly 1100 articles. The collection continues to grow as new projects are added and new articles published. We have entered the bibliographies and associated abstracts into a computer database (NOTE: not all articles have been abstracted). While the establishment of the NPLC and the computer database were not part of the original agreement, the collection of the articles was inevitable so that unnecessary duplication of research efforts was avoided, research techniques could be evaluated and adopted, and new products and management techniques could be learned. Establishing a database to manage the collection was a necessary outcome to make management and retrieval of articles easier for the growers and researchers involved in the project.

The NPLC database will be made available to the industry and other interested groups in the form of topic-based lists. The full database is included as well as 50 topic based lists and a list of keywords that can be used to search the electronic database. The number prefixing each reference is a unique record number assigned to each entry in the database. This unique number allows quick retrieval of articles from the NPLC. Copies of papers can be made for interested growers (and others) at some cost per article to recover the cost of reproduction and postage. The NPLC will be housed at the Department of Plant Sciences, University of Saskatchewan so horticulture students may also have access to the collection.

Topic Based Lists (Numbers correspond to ID number in PNLC database)

Absorbants and Wetters
896 - 905, 955, 1052, 1063

Acclimation
190, 464, 467, 786, 813, 986 – 989, 992, 1005, 1059

Acidification
184, 611, 613, 615, 617 – 620, 646, 683, 684, 688, 689 – 694, 696, 698 – 703, 705, 710, 712, 713, 717 – 720, 722, 724, 768, 776, 908, 917, 918, 958 – 960, 1013, 1089

Analytical Methods
78 – 81, 127, 131, 145, 147, 159, 164, 165, 185, 198, 200 – 211, 213 – 216, 218 – 221, 223, 225 – 234, 236, 237, 306, 349, 418, 531, 618, 620, 638 – 644, 649, 655, 669, 672, 673, 677, 683, 699, 707, 708, 738, 739, 742, 743, 764, 767, 846, 849, 881, 906, 907, 914, 918, 920, 929, 970, 1039, 1061

Bare Root Nursery Stock
58, 95, 189, 474, 558, 756, 770, 873, 949, 950, 977, 997, 998, 1045, 1090

Chilling & Freezing: Injury, Acclimation and Prevention
12, 58, 93, 175, 190, 194, 195, 223, 460, 464, 467, 468, 486, 505, 562, 563, 584, 588 – 591, 602, 606, 607, 621, 630, 650, 670, 671, 779, 780, 788, 810, 813, 823, 981 – 984, 988, 989, 992, 995, 999 – 1001, 1003 – 1005, 1059, 1064, 1072, 1082, 1086, 1088

Containers, Container Production
1, 10, 12, 45 – 47, 49, 51, 53, 56 – 58, 60, 67, 85, 87, 89, 91, 94 – 97, 100 – 111, 113 – 124, 133, 135 – 146, 148 – 150, 152, 153, 160 – 163, 174, 180, 182, 199, 201, 204, 222, 224, 227, 242 – 246, 249 – 253, 269, 270, 272, 274, 276, 278, 282, 282 – 284, 286, 287, 289, 297, 299, 301, 308, 309, 313, 316 – 319, 321, 325, 368, 370, 372, 378 – 380, 387 – 390, 392 – 398, 400, 401, 403, 406, 407, 412, 413, 416, 421, 423, 424, 426 – 428, 430, 431, 433 – 435, 437, 438, 443 – 445, 454 – 456, 460 – 463, 468 – 471, 473, 474, 475 – 479, 481 – 484, 488, 489, 499, 504, 507 – 509, 514, 520, 521, 523, 524, 528 – 530, 532, 536 – 538, 542, 547, 548, 550 – 552, 558, 561, 567, 612, 621 – 624, 626, 633, 637, 640 – 643, 645 – 647, 678, 679, 682, 711, 726, 727, 729 – 733, 735 – 737, 748, 754, 755, 757 – 759, 762, 765, 769, 771 – 773, 781 – 783, 787, 790, 791, 793, 795, 816, 818 – 820, 826, 838, 839, 841 – 845, 849, 850, 852 – 861, 865 – 873, 877 – 879, 883, 896, 898 – 900, 903, 915, 944, 948, 952 - 975, 977, 978, 982 – 984, 986 – 989, 992, 994, 995, 997, 999, 1000, 1003, 1004, 1006, 1007 – 1009, 1011, 1012, 1015, 1017 – 1019, 1021 – 1024, 1026, 1032, 1046, 1052 – 1054, 1058, 1071, 1072, 1079, 1082, 1086, 1088

Copper
1, 45, 46, 49, 53, 57, 118 – 120, 489, 684, 693, 727, 814 – 836, 838 – 883, 918, 979, 1046

Cover Crops (Nursery Aisle Ground Covers)
186, 187, 196, 300, 335, 377, 706, 760, 763, 792, 813, 856, 950, 999, 1060, 1072, 1084, 1086

Cultural Methods
4, 186, 320, 329, 393, 407, 418, 476, 478, 481, 482, 510, 512, 551, 564, 587, 626, 627, 689, 729, 730, 732, 744, 792, 813, 816, 844, 857, 861, 872, 873, 878, 940, 953, 962, 988, 990, 1022, 1023, 1048, 1050, 1055, 1058, 1073, 1084, 1085, 1090

Disease Management (also Disorders)
560, 593, 654, 656, 657, 661, 696, 740, 746, 784, 824, 825, 892, 895, 918 – 920, 939, 940, 988, 1027, 1029, 1047

Dormancy and Hardiness
93, 175, 190, 194 – 196, 454, 467, 468, 496, 493, 498, 505, 562, 584, 586, 589 – 591, 602, 608, 621, 650, 667, 670, 735, 784, 788, 810, 813, 981, 982, 984, 986, 987, 992, 1001, 1003, 1005, 1065, 1070, 1081, 1082, 1088

Drought Management
423, 458, 480, 930, 932

Fertilizer and Fertility
2, 4, 7 – 9, 12, 15, 16, 18, 19 – 21, 25 – 28, 29, 58, 95, 125 – 132, 135 - 140, 143, 144, 146 – 151, 156, 157, 159, 160 – 166, 169, 171, 177, 179 – 185, 187, 196, 198 – 201, 205, 206, 208, 209, 212, 215, 217, 219, 221, 222, 228, 229, 231, 418, 428, 438, 443, 455, 457, 473, 479, 482, 487, 489, 506 – 509, 521, 532, 533, 541, 548, 554, 556, 561, 576 – 578, 600, 603, 605, 609 – 611, 614, 616, 619, 620, 644, 645, 647, 648, 651 – 653, 668, 678, 685, 689, 693 – 695, 697 – 699, 706, 710 – 713, 715, 721, 724, 728, 729, 731, 732, 733, 736, 744, 753, 761, 762, 765, 767, 769, 771 – 773, 776, 781, 1782, 785, 794, 803, 809, 862, 915, 957, 969, 973, 976, 1003, 1005, 1013, 1051, 1053, 1061, 1062, 1064, 1071

Field Production
90, 92, 116, 121 – 123, 125, 154, 187, 209, 245, 418, 533, 543, 560, 606, 676, 680, 683, 705, 760, 770, 785, 799 – 802, 884, 914, 929, 979, 980, 997, 998, 1001

Foliar Nutrient Application
2 – 29, 31, 32, 34, 36, 38, 44, 51, 61, 65, 148, 166 – 173, 195, 205, 207, 209, 219, 237, 415, 554, 556, 560, 570, 573 – 577, 579, 580, 582, 604, 616, 648, 651 – 653, 665 – 669, 693, 714, 721, 914, 1010, 1062, 1064, 1081

Fungicide
4, 442, 535, 817, 821, 824, 828, 832 – 836, 862, 1060

Media
10, 58, 96, 101, 152, 162, 163, 184, 199, 202, 227, 247, 270, 274, 289, 297, 379, 423, 430, 433, 462, 469, 471 – 473, 476, 477, 488, 489, 495, 506, 509, 516, 550, 559, 565, 567, 639, 640 – 643, 646, 682, 730 – 732, 736, 748, 755, 759, 774, 786, 793, 873, 878, 880, 898 – 901, 906, 915, 952 – 972, 974, 975, 977, 978, 999, 1012, 1035, 1052, 1053, 1072

Herbaceous Perennials
32, 44, 60, 62, 242, 370, 372, 495, 496, 510, 528, 529, 530, 557, 558, 561, 564, 596, 612, 621 – 627, 630 – 633, 635, 637, 654, 655, 658 – 660, 662, 731, 734, 779, 780, 782, 793, 845, 866, 872, 901, 999, 1007 – 1010, 1048, 1055 – 1057, 1065, 1067 – 1069, 1072 – 1079, 1081 – 1083, 1085 – 1090

Herbicide
158, 186, 187, 242, 248 – 250, 253, 255 – 259, 269, 271 – 273, 275 – 290, 292, 295 – 299, 302, 304 – 307, 310 – 313, 315, 316, 318 – 326, 328, 330, 335, 339, 342, 346 – 352, 354 – 356, 359, 360, 367 – 395, 398 – 411, 414, 415, 417 – 422, 442, 478, 528 – 530, 541, 592, 675, 676, 679 – 681, 749, 766, 783, 789, 790, 791, 794, 795, 797, 799 – 802, 897, 962, 980, 1007, 1008, 1023, 1080

Innovations
106, 382, 425, 438, 526, 709

Insects and Insecticides
19, 356, 442, 555, 571, 656, 657, 663, 709, 825, 895, 897, 1028, 1047,

Integrated Pest Management
365, 407, 442, 555, 663, 706, 709, 723, 766, 786, 939, 1060

Iron chlorosis
15, 489, 626, 683, 684, 688, 693, 694, 829, 911, 913, 916 – 920

Irrigation
147, 148, 152 – 156, 162, 164, 209, 222, 224, 231, 282, 302, 306, 313, 332, 335, 412, 423 – 437, 452, 480, 504, 506 – 508, 511, 513, 522, 526, 534 – 539, 541 – 5553, 587, 612, 628, 647, 683, 685, 691, 726, 730, 731, 735, 737, 744, 746, 747, 751, 753, 776, 782, 803, 805 – 809, 878, 899, 900, 912, 925 – 932, 934, 962, 966, 1009, 1013, 1054

Landscaping
103, 108, 224, 276, 369, 405, 414, 420, 605, 658, 659, 709, 775, 837, 859, 885, 936, 1001, 1032, 1050, 1087

Lawns and Turf
257, 306, 405, 454, 661, 725, 1080

Liming
487 – 489, 615, 685, 686, 690, 712

Harvest (Field Production)
94, 454, 574, 585, 601, 619, 756, 770, 777, 851, 979, 993, 997, 998

Micropropagation
364, 492, 494 – 496, 500 – 502, 517, 518, 630, 786, 792, 830, 880, 1078

Mulch
186, 187, 191, 367, 401, 404, 418, 478, 485, 549, 603, 606, 607, 837, 962, 989, 1005, 1060, 1084

Nursery Production
129, 131, 132, 135, 138, 148, 150, 151, 154, 156, 157, 159, 161, 182, 189, 271, 282, 284, 317, 321, 369. 376, 402, 405, 407, 413 – 415, 420, 423, 425 – 427, 432, 438, 439, 454, 459, 463, 471, 483, 512, 525, 520 – 526, 528 – 530, 535, 536, 539, 542, 544, 546 – 548, 550, 565, 605, 622 – 624, 629, 637, 645, 647, 655, 661, 662, 675, 690, 711, 737, 751, 792, 795, 838, 839, 842, 843, 853 – 855, 858, 861, 865, 867 – 870, 877, 878, 912, 914, 943, 946, 947, 949 – 951, 956, 962, 977, 980, 988, 1000, 1004, 1006, 1016, 1023, 1026, 1032, 1041, 1071, 1079, 1084

Pest and Pesticide
19, 21, 88, 339, 347, 356, 358, 418, 419, 438, 441, 555, 582, 629, 654, 656, 661, 663, 664, 709, 795, 796, 821, 822, 825, 887, 892, 897, 909, 1028, 1060, 1090

Pot-in-Pot Production
118, 853, 879, 1015 – 1024, 1032

Plant Descriptions
598, 631, 632, 784, 811, 812, 884 – 895, 1027, 1066, 1067

Plant Growth Regulators
1, 30 – 42, 44 – 57, 60 – 66, 68 – 78, 118 – 120, 235, 442, 494 – 498, 584 – 586, 588 – 591, 626, 649, 650, 670, 671, 682, 774, 777, 778, 789, 804, 830, 850, 864, 882, 935, 948, 990, 996, 1002, 1010, 1011, 1012, 1014, 1034, 1044, 1045, 1077, 1081

Pollution from Nursery Production
21, 156, 158, 159, 313, 339, 341 – 344, 346, 350, 354, 356, 360, 412, 438, 687, 701, 702, 710, 712, 722, 815

Propagation
84, 89, 112, 116, 379, 445, 454, 484, 491, 514, 515, 517, 519, 525, 547, 568, 595 – 597, 625, 630, 660, 750, 778, 786, 816, 852, 853, 889, 901, 964, 985, 1010, 1016, 1026, 1034 – 1037, 1078, 1081, 1085, 1089

Pruning
38, 42, 49, 57, 64, 91, 102, 108, 141, 188, 436, 570, 814, 824, 839, 814 – 843, 860, 861, 865, 868 – 870, 877, 879, 883, 885, 941, 946, 962, 1005, 1014, 1038 – 1044, 1066, 1049 – 1051, 1090

Rice Hulls (as Mulch and Media Amendments)
470, 611, 617, 977

Roots, Roots, and More Roots
12, 31, 45, 46, 49, 53, 57, 58, 87, 91, 95 – 97, 102 – 108, 110, 112, 114, 117, 121, 124, 153, 163, 188, 189, 223, 231, 305, 379, 433, 436, 443, 444, 468, 473, 474, 499, 500,503, 535, 539, 560, 567, 570, 597, 628, 685, 686, 713, 727, 754, 756, 758, 767, 770, 778, 786, 810, 813 – 816, 821, 826, 831, 838 – 845, 847, 849 – 861, 863 – 866, 868 – 874, 876, 877, 880, 883, 885, 901, 930, 949, 962, 965, 977, 979, 982, 984, 986, 989, 997, 998, 1008, 1013, 1014, 1015, 1022, 1023, 1025, 1026, 1030, 1033, 1034 – 1036, 1038 – 1046, 1051, 1061, 1085, 1090

Seeds and Seedlings
12, 28, 30, 49, 50, 58, 66, 95, 97, 99, 100, 102, 110 – 113, 142, 188, 194, 195, 199, 204, 221, 223, 237, 301, 317, 327, 376, 396, 434, 460, 467, 489, 550, 559, 564, 602, 603, 619, 628, 667, 681, 682, 684, 697, 750, 792, 814, 815, 823, 840, 841, 849, 853, 854, 856, 861, 869, 871, 872, 876, 877, 883, 969, 971, 977, 982, 1004, 1041, 1044, 1057, 1058, 1059, 1062, 1063, 1068 – 1070, 1085, 1089

Shelterbelts
525, 886

Soil
21, 26, 47, 51, 55, 56, 61, 81, 113, 131, 132, 151, 159, 162 – 164, 166, 178, 184 – 187, 199, 200, 208, 210, 211, 212, 227 – 229, 232, 289, 300, 302, 303, 304, 334, 335, 336 – 338, 340, 346, 350 – 354, 357, 359, 361, 362, 364, 366, 399, 415, 418, 430, 443, 469, 488, 506, 508, 531, 550, 606, 609 – 611, 613, 615, 617 – 620, 639 – 643, 646, 677, 683 – 705, 710 – 713, 715, 717 – 720, 722 – 725, 728, 730, 736, 741 – 743, 748, 766, 782, 793, 807, 827, 837, 846, 862, 875, 883, 897, 899, 900, 902, 905, 913, 914, 916 – 925, 928, 929, 933 – 935, 950, 955, 961, 969, 974, 977, 999, 1013, 1031, 1056, 1059, 1061, 1063, 1081, 1084

Soilless (See also Media)
162, 163, 199, 227, 430, 508, 643, 506, 730, 899, 900, 969, 1059

Solarization
527, 950

Sulfur
5, 150, 473, 609 – 611, 613 – 615, 617 – 620, 683 – 685, 687, 690 – 705, 710 – 713, 715, 717 – 725, 862, 878, 915 – 919, 1089

Surfactants
16, 389, 591, 897, 899 – 901

Temperate Fruits
497, 498, 556, 573, 581, 583, 584, 588, 590, 591, 650, 666, 667, 669, 670, 714, 777, 930, 980, 990, 991, 996, 1014, 1043, 1064

Transplanting
49, 57 - 59, 95, 97, 102 – 105, 108, 111, 113, 175, 176, 188, 189, 221, 445, 469, 539, 546, 804, 816, 8541, 843, 844, 852, 858, 861, 866, 871 – 873, 883, 885, 1004, 1013, 1022, 1026, 1045, 1059

Vernalization and Forcing
562, 633, 635, 664, 779, 780, 1048, 1059, 1082

Water
17, 79, 88, 107, 108, 147, 154, 159, 162, 175, 186, 187, 282, 295, 311, 313, 339, 342 – 345, 350, 353, 356, 357, 362, 385, 412, 418, 423, 425 – 427, 430, 431, 437, 451, 480, 513, 535, 537, 538, 541, 550, 551, 553, 610, 628, 636, 647, 683, 685, 686, 722, 726, 730, 737, 748, 755, 767, 793, 808, 809, 844, 846, 861, 871, 878, 899, 900, 902, 904, 907 – 912, 922, 923, 926, 928, 929 – 932, 955, 975, 977, 1005, 1026, 1052, 1056, 1061, 1063, 1084

Weeds and Weed Control
94, 179, 186, 238 – 241, 243 – 246, 250 – 252, 255 – 257, 268, 269, 271 – 273, 276 – 279, 281, 283 – 286, 290, 292, 293, 296 – 307, 310, 312, 313, 315 – 321, 323 – 330, 368, 369, 371, 373 – 388, 390 – 395, 400 – 403, 405 – 411, 413 – 421, 453, 461, 466, 470, 478, 512, 525, 527 – 529, 566, 675, 676, 679, 680, 716, 727, 734, 749, 760, 763, 790 – 792, 797 – 802, 962, 980, 1007, 1008, 1023, 1058, 1060, 1070

Winter Survival and Damage
93, 190, 196, 338, 446, 468, 486, 589, 602, 621, 650, 670, 784, 788, 941, 983 – 986, 989, 999, 1001, 1003 – 1005, 1048, 1059, 1065, 1082, 1088

Index: The PNLC electronic database can be searched using up to any three of the following keyword terms to produce a client requested topic list

A horizons
ABA
ABA flux
Abelia grandiflora
Abies amabilis
Abies grandis
abiotic injuries
abnormal development
abscisic acid
abscission
absorbants
absorbents
absorption
Abutilon theophrasti
acanthaceae
acclimatino
acclimation
acclimatization
accuracy
Acer
Acer ginnala
Acer mono
Acer platanoides
Acer rubrum
Acer saccharinum
Acer saccharum
Acer tataricum
Acer truncatum
Acer x freemanii
acetochlor
Achillea
Achillea millefolium
acid deposition
acid injection
acid rain
acid soils
acid treatment
acidification
acids
acidulants
acifluorfen
actinomycetales
adjuvants
adsorption
adventitious bud formation
adventitious roots
adventitious shoots
adverse effects
aeration
Afghan pine
age
age of trees
agricultural chemicals
agricultural entomology
agricultural soils
agriculture
Agrilus bilineatus
Agrobacterium tumefaciens
agroecosystems
agroforestry systems
agronomic characteristics
Agrostis stolonifera
air pollutants
air pollution
air pruning
air root pruning
air temperature
air temperature.
Alabama
Alabama .
alachlor
alanite
Alar
alberta
Alberta spruce
Alcea rosea
alcohol dehydrogenase
aldicarb
Alexis Millardet
alfisols
algae control
algal growth
alkaline
alkaline soils
alkalinity
allium
almonds
alternative
aluminium
aluminum
aluminum sulfate
Amaranthus retroflexus
Ambrosia artemisiifolia
Amelanchier
Amelanchier laevis
amendment
amendments
amenity and recreation areas
amenity planting
amide herbicides
amino acids
amino nitrogen
ammonia
ammonium
ammonium compounds
ammonium nitrate
ammonium nitrogen
ammonium sulfate
Ampelopsis
amur
anaerobiosis
analysis
analytical analysis
analytical mehods
analytical method
analytical methods
analytical techniques
ancymidol
Angiospermae
angiosperms
anhydrous amonia
annual habit
annuals
antagonism
anthocyanins
antiauxins
antidessiccant
antifeedants
antitranspirants
apical dominance
Apium graveolens
apple
apple pomace
apples
application
application date
appliication rates
application date
application date.
application equipment
application methods
application rate
application rates
application rates.
application techniques
application-rates
applications
apricots
aquatic environment
aquifers

Aquilegia
arable land
arable soils
Arachis hypogaea
arboriculture
arborvitae
arid regions
arizona
arthropod pests
ascorbic acid
Asparagus densiflorus
aspen
Aspergillus flavus
Aspergillus terreus
assessment
Asteracea
astilbe
asulam
atomic absorption spectrophotometry
atrazine
automatic control
autumn
auxin
auxins
availability
available water
available water capacity
Avena sativa
azalea
azipro:ryne
B horizons
ba
Bacillus circulans
Bacillus megaterium
bag
bags
baits
BAP
bare fallow
bare root
bare root stock
bare rooted stock
bare-root stock
bareroot
bark
bark compost
bark storage protein
barley
barley straw
barriers
basal area
basal dressings
BC25102 Coniferopsida Plants
bedding plants
Begonia
Begoniaceae
Beloperone guttata
bending strength
benefin
bensulide
benzyladenine
benzylaminopurine
Berberis thunbergii
Betula
Betula nigra
Betula papyrifera
Betula pendula
Betula pubescens
bifenox
Bignoniaceae
binding
binding sites
bioassays
bioavailability
biochemistry
biodegradation
biofertilizers
biological activity in soil
biological assay
biological competition
biological control
biological control agents
biological techniques
biologicals
biology
biomass
biomass production
biomass synthesis
biosolids
biostimulant
biosynthesis
biotechnology
blankets
blossom end rot
blueberry
book list
Bordeaux mix
Bordeaux mixture
boron
boron fertilizers
bottomless
bottomless containers
bougainvillea
bracts
branches
branching
Brassica oleracea
Brassica campestris
Brassica nigra
Brassica oleracea
Brassica oleracea var botrytis
brassica oleracea var. botrytis
Brassica oleracea var. capitata
breeding
british columbia
brix
broadcasting
broadleaves
broccoli
bromide
browsing damage
bud break
bud culture
bud development
bud initiation
budding
Buddleja davidii
buds
buffering capacity
bulk density
buried drip irrigation
burns
businesses
Buxus microphylla
Buxus sempervirens
cabbages
CAD
cadmium
calacareous soils
caladium hortulanum
calamagrostis
calamagrostis x acutiflora
calcareous rocks
calcareous soils
calcium
calcium carbonate
calcium chloride
calcium ions
calcium nitrate
calibration
california
California .
calipers
callus
callus formation
campanula
camphechlor
Canada
candy
cankers
canna
canopy

capacity
capillary irrigation
capillary mat irrigation
capillary sandbed
capillary water
capital
Capsicum annuum
carbaryl
carbetamide
carbofuran
carbohydrate
carbohydrates
carbon
carbon nitrogen ratio
carbon partitioning
carbonates
Cardamine hirsuta
carotenes
carts
carya glabra
carya illinoinensis
case studies
castanea mollissima
cation exchange
cation exchange capacity
cauliflowers
Cedrela odorata
Cedrus deodara
celery
cell cycle
cell division
cellugro
cellular biology
cellulase
Celosia argentea var. cristata
ceratostigma
Cercis canadensis
CGA 82725
Chamaecyparis
changes
characteristics
cheddar pink
chelates
chemical constituents of plants
chemical analysis
chemical application
chemical composition
chemical control
chemical damage
chemical properties
chemical pruning
chemical pruning.
chemical reactions
chemical renovation
chemical root pruning
chemical treatment
chemical vs
chemicals
Chenopodium album
cherries
chick weed
chilling
chilling injury
chilling requirement
chilling tolerance
Chinese pistache
chloramben
chlorides
chlorine
chlormequat
chloroform
chlorophyll
chlorophyll fluorescence
Chlorophytum
Chlorophytum comosum
chloroplasts
chlorosis
chlorpropham
chlorpropham + PPG-124
chlorthal dimethyl
cholorphyll determination
chrysanthemum
chrysanthemum morifolium
chrysanthemums
Cicer arietinum
citrus
citrus fruits
Citrus sinensis
classification
clay
clay loam soils
clay pots
clay soils
clearcutting
Clematis
clementines
climatic zones
clofibric acid
clones
clopyralid
clovers
coastal plain soils
coatings
coconuts
coir
colaboration
colchicine
cold
cold acclimation
cold damage
cold hardening
cold hardiness
cold injury
cold resistance
cold storage
cold stress
cold tolerance
cold zones
cold-resistance
color
colour
combustion
comparisons
competitive ability
components
composition
composts
computer
computer controlled irrigation
computer software
computer techniques
concentration
conifer
Coniferopsida
coniferous forests
conifers
conservation
conservation tillage
constituents
constraints
construction
container
container design
container grown
container grown plant
container grown plants
container grown plants.
container media
container nursery
container production
container size
container volume
container, bottomless
container-grown
container-grown plants
container-grown stock
containers
containers production
contamination
contamination preventation
control
controlled droplet application

controlled release
controlled release fertilizer
controlled release fertilizers
controlled release fertlizer
controlled-release
controllers
Conyza canadensis
copper
copper carbonate
copper fabric
copper fungicides
copper hydroxide
copper napthenate
copper paint
copper sulfate
copper treated pots
coreopsis
Coreopsis grandiflora
cork spot
corktree
Cornaceae
Cornus florida
Coronilla varia
correlation
Cortaderia selloana
cost analysis
cost benefit analysis
cost effective
costs
Cotoneaster dammeri
cotton
cover crop
cover crops
coverage
covers
crabgrass
Crataegus
Crataegus phaenopyrum
CRF
Crocosmia crocosmiiflora
crop yield
crop damage
crop density
crop establishment
crop growth stage
crop management
crop mixtures
crop production
crop protection
crop quality
crop quality.
crop residues
crop sensitivity
crop weed competition
crop yield
cropping systems
crops
crown
crown gall
cryoprotectants
Cryptomeria japonica
CuCO3
cucumbers
Cucumis sativus
cucurbit vegetables
Cucurbita moschata
culinary herbs
cultivar identification
cultivar protection
cultivars
cultivation
cultural control
cultural management
cultural methods
cultural practice
cultural practices
cultural weed control
cultural-control
cultural-methods
culture media
cupper hydroxide
Cupressocyparis leylandii
cupric carbonate
cupric chloride.
cupric hydroxide
cut flowers
cutting
cutting frequency
cuttings
cyanazine
Cyclamen
cyclic fluctuations
cyclic irrigation
cycling
cycloheximide
Cynodon dactylon
Cyperus esculentus
cytokinin
cytokinine
cytokinins
Dactylis glomerata
dahlia
damage
daminozide
Daphne burkwoodii
dark
daucus carota
daughters
DCPA
decomposition
decontamination
DED
deep plowing
deep supercooling
deep tillage
deer control
deficiency
deficiency diseases
defoliant
defoliants
defoliation
deformation
degradation
delaware
delphinium
Dendranthema
Dendranthema morifolium
denitrification
density
deodar cedar
dephenamid
deposition
depth
description
description, species
desert plants
desiccation
design
design criteria
desorption
dessication
detection
determination
development
dextrel
diagnosis
diameter
Dianthus deltoides
Dianthus gratianopolitanus
'Firewitch'
Dianthus sp.
diazinon
dicalcium phosphate
dicamba
dichlobenil
Dicotyledones
dieback
differentiation
diffusate-conductivity method
diffusion
Digitalis purpurea
Digitaria sanguinalis

dimensions
dinitroaniline herbicides
diphenamid
Diplocarpon rosae
disc
disease
disease control
disease prediction
disease resistance
diseases
disinfection
disorders
dispersion
display garden
distribution
dithiopyr
diurnal variation
diuron
diuron .
DNA
dna binding proteins
dolomite
dolomitic limestone
domestic water supply
dormancy
dormancy breaking
dosage effects
Dracaena fragrans
drainage
drainage water
drench
drinking quality
drinking water
drip irrigation
DRIS
drought
drought stress
dry farming
dry matter
dry matter accumulation
dry matter accumulation.
dry matter distribution
dry matter.
dry weight
dry-matter
duration
dust
Dutch elm disease
dwarfing
earliness
EC
Echinacea purpurea
Echinochloa crus galli
Echinochloa frumentacea
Eclipta alba
econometric models
economic evaluation
economic information
economics
ecosystems
ecotypes
edaphic factors
effects
efficacy
efficiency
effluents
egypt
Elaeagnus pungens
electrical conductivity
electrical resistance
electrical resistance controller
electrolytes
elemental sulfur
Eleusine indica
ELISA
elongation phase
Elymus repens
embryo culture
emergence
emulsifiable concentrates
encapsulation
endogenous growth regulators
endothal
Enkianthus
entisols
entomology
EnviroGuard Commercial Weed Block
environment
environmental factors
environmental impact
environmental protection
environmental sensor
environmental temperature
enzyme activity
enzyme inhibition
enzymes
EPA
EPTC
equations
equipment
Eriobotrya japonica
erodium
erosion
erosion control
errors
establishment
establishment .
esterases
estimation
ethephon
ethrel
ethylene
ethylene production
ethylene releasers
etiolation
eucalyptus globulus
euonymus
Euonymus fortunei
Euphorbia
euphorbia pulcherrima
Euphorbia supina
eutrophication
evaluation
evaporation
evapotranspiration
everglades
evergreen
evolvulus
Evolvulus glomeratus
Evolvulus tenuis
exchange acidity
exchangeable cations
exchangeable hydrogen
exchangeable sodium
extractants
extraction
extracts
extraorgan freezing
exudation
fabaceae
fabric
fabric container
fabric containers
fabric grow bag
fabric grow bags
fabrics
facilities
factor analysis
Fagopyrum esculentum
Fagus sylvatica
fall
fallow
falls
farmyard manure
FDR
feeding behaviour
felling
fenoxaprop
fenoxaprop-ethyl
fentin hydroxide
ferrous sulfate

fertigation
fertility
fertilization
fertilizer
fertilizer levels
fertilizer application
fertilizer comparison
fertilizer contamination
fertilizer management
fertilizer placement
fertilizer rates
fertilizer requirement determination
fertilizer-requirement
fertilizers
fertilizier
fertilzer
Festuca arundinacea
Festuca rubra
fiber quality
fiber pots
fibreglass disk
Ficus leprieurii
field
field crops
field experimentation
field grown
field grown plants
field production
field tests
field-grown nursery crops
filtration
fire blight
firmness
fixed costs
flex crenata 'Compacta'
florel
floriculture
florida
Florida .
flower drop
flowering
flowering .
flowering date
flowers
fluazifop
fluazifop-butyl
fluazifop-P
fluchloralin
fluorescence
flurprimidol
foams
foliage
foliar application
foliar spraying
foliar analysis
foliar application
foliar diagnosis
foliar feed
foliar feeding
foliar fertilization
foliar fertilizer
foliar nutrients
foliar nutrition
foliar spray
foliar spraying
foliar sprays
foliar uptake
foliar-application
foliar-nutrition
foliar-spraying
food contamination
food plants
foraging
forcing
forest
forest damage
forest decline
forest economics
forest nurseries
forest nursery soils
forest pests
forest soils
forest trees
forestry
forests
formulations
forsythia
Forsythia europaea
Forsythia intermedia
fosetyl
Fragaria ananassa
france
Fraxinus
Fraxinus pennsylvanica
freeze damage
freeze protection
freeze thaw cycles
freezing
freezing injury
frequency
fresh weight
frost
frost injury
frost protection
frost resistance
frozen conditions
frozen storage
fructose
fruit
fruit bud
fruit crops
fruit crops;
fruit drop
fruit production
fruit set
fruit trees
fruit vegetables
fruit-trees
fruiting
fruits
fruits set
fungicide
fungicide application
fungicides
fungus-control
Fusarium
Fusarium oxysporum
Fusarium solani
ga
Gaillardia
Gaillardia grandiflora
galls
gamma radiation
Gardenia jasminoides
gardening
gas chromatography
gas exchange
gauges
gelatin
gels
gene expression
gene transfer
genes
genetic linkage map
genetic mapping
genetic regulation
Genetics
genomes
genotypes
geographical variation
georgia
geotextiles
geranium
germination
Geum
gibberellic acid
gibberellin
gibberellin A4A7
gibberellins
girdling
girth
glass formation

gloquat C
glucose
glutamic acid
glutamine
Glycine max
glyphosate
golf green soils
Gossypium hirsutum
gossypium hirsutum
grading
grafting
grain
gramineae
granite
granular
granular application
granular herbicide
granular matrix
granular matrix sensor
granules
grapefruits
grapes
grass strips
grasses
grassland soils
grasslands
Great Britain
greenhouse
greenhouse crops
greenhouse culture
greenhouse experimentation
greenhouse production
greenhouse soils
greenhouse tests
greenhouses
ground cover
ground cover plants
ground surface spraying.
groundcover
groundwater
groundwater pollution
grow bag
grow bags
growing media
growing media.
growing medium
growth
growth analysis
growth effects
growth inhibitors
growth promoters
growth rate
growth rate.
growth regulators
growth responses
growth retardants
growth retardation
growth stages
growth yield
guidelines
gums
Gymnospermae
Gymnosperms
gyphosate
gypsum
gypsum block.
gyttja
habit
habitats
Halesia
half life
haloxyfop
haloxyfop-ethoxyetheyl
handling
hardening
hardiness
hardiness zones
hardwoods
hardy
harvest
harvest index
harvesting
harvesting date
hawaii
hay
heat stress
heat sums
heat transfer
heathlands
heavy metal
heavy metals
Hebe
hedera
height
height reduction
Helianthus
Helianthus annuus
Hemerocallis
herbaceous perennial
herbaceous perennials
herbicidal properties
herbicide
herbicide application
herbicide classification
herbicide combinations
herbicide contamination
herbicide damage
herbicide formulations
herbicide metabolism
herbicide mixtures
herbicide rates
herbicide recommendations
herbicide residues
herbicide resistance
herbicide selectivity
herbicides
Herbicides Ohio Application
Heuchera
Heuchera sanguinea
Hibiscus
hilling
histones
history
histosols
holly
Hordeum
Hordeum vulgare
horizons
horticultural crops
horticultural-crops
horticulture
hosta
Hosta sieboldiana
Hosta tokudama
Hosta undulata
Hubbard Brook experimental forest
humates
humic acids
humic matter
husks
hybrids
hydrogel
hydrogen
hydrogen sulfide
hydrology
hydrophilic polymers
hydroponic
hydroponics
hydroxysulfate minerals
hypocotyls
IAA
IBA
IBDU
ice damage
ice nucleation
idaho
Ilex
Ilex attenuata
Ilex cassine
Ilex cornuta
Ilex cornuta 'Burford'
Ilex cornuta Burford

Ilex crenata
Ilex crenata 'Helleri'
Ilex opaca
Ilex vomitoria
illinois
imbibition
imidazoles
impatiens
impatiens walleriana
impatients
improvement
in vitro
in vitro culture
INA bacteria
inceptisols
incorporation
indexes
indexes of nutrient availability
india
indiana
induction
industry
infection
infiltration
inflorescences
infrared thermography
ingredients
inground fabric gro-bag
inhibition
inhibitor
initiation
injector
injectors
injuries
injurious factors
injury
innovation adoption
innovations
inoculum
inorganic salts
insect
insect control
insect pests
insecticide
insecticides
insects
instruments
insulating materials
integrated pest management
integrated weed control
interactions
internodes
interplanting
interspecific hybridization
interspecific hybrids
Intertec
ion uptake
ion-selective electrode
ions
iowa
IPM
Iris germanica
iron
iron chlorosis
iron fertilizers
irradiation
irrigated conditions
irrigated farming
irrigation
irrigation equipment
irrigation management
irrigation requirements
irrigation return flow
irrigation scheduling
irrigation scheduling.
irrigation system
irrigation system components
irrigation systems
irrigation systems. design . nurseries
. guidelines . indiana .
irrigation timing
irrigation water
isazofos
isolation
isoproturon
isoxaben
israel
italy
japan
Japanese black pine
Jouttuynia
Juglandaceae
juglans nigra
juglans regia
juice quality
Juniperus
Juniperus 'Youngstown'
Juniperus chinensis
Juniperus chinensis 'Pfitzeriana'
Juniperus chinensis 'San Jose'
Juniperus chinensis pfitzeriana
Juniperus conferta
Juniperus horizontalis
Juniperus horizontalis cv. Plumosa
Compacta Youngstown
jurbanite
juvenility
kamposan
kentucky
kenya
kinetics
Koelreuteria
Koelreuteria bipinnata
laboratories
laboratory methods
laboratory techniques
laboratory tests
labour saving
lactofen
Lactuca sativa
Lagerstroemia
Lagerstroemia fauriei
Lagerstroemia indica
lagerstroemia indica x fauriei
land improvement
landscape
landscape design
landscape gardening
Landscape nurseries
landscape physiology
landscape specifications
landscaping
Lange Bramke model
Lantana camara
Lantana montevidensis
lateness
latex
latex paint
Lavandula angustifolia
lawn
lawns and turf
Lawns Weed control
leachate
leachates
leachates .
leachateselectrical conductivity
leaching
lead
leaf analysis
leaf age
leaf analysis
leaf area
leaf area.
leaf conductance
leaf fall
leaf mold
leaf temperature
leaf water potential
leaf water potential.
leaves
leaves .
Leea coccinea.

legislation
legumes
length
Lens culinaris
Lepidium virginicum
lespedeza
Lespedeza cuneata
Lespedeza juncea
Leucanthemum
Leucanthemum maximum
Leucanthemum vulgare
Liatris pycnostachya
Liatris spicata
lifting
light
light intensity
light relations.
Ligustrum japonicum.
Lilium
lime
lime mineral
liming
liming materials
lincomycin
linings
linings .
lint
linuron
liquid fertilizers
liquid-fertilizers
Liquidambar styraciflua
Liriodendron tulipifera
Liriope muscari
Litchi chinensis
literature reviews
litter
live mulches
live oak
loam soils
loblolly pine
lodgepole pine
Lolium multiflorum
Lolium perenne
longevity
loosening
loss prevention
losses
losses .
losses from soil
louisiana
low input agriculture
low temperature injury
low temperature storage
low volume spraying
lower saxony.
lucerne
lupins
Lupinus
Lupinus angustifolius
Lycopersicon esculentum
lysimeters
lysimetry
Maackia amurensis
macronutrients
magic model
magnesium
magnetic treatment system
Magnolia grandiflora
Magnolia soulangiana
Maine
maize
Malus
Malus domestica
malus pumila
Malus sp.
Malus x zumi
management
management practices
mandarins
manganese
manganese fertilizers
Mangifera indica
Manitoba .
manual
manuals
manures
maple
maples
marigold
marigolds
marine areas
marketing
maryland
Massachusetts
materials
materials testing
mathematical models
matric potential
matrices
mats
maturation
maturation period
maturity
maturity stage
measurement
measurement .
mechanical damage
mechanical methods
mechanical weed control
media
media amendment
media pH
Medicago sativa
medicinal plants
medium
medium, alternative
mefluidide
Melilotus alba
Melilotus officinalis
Meloidogyne hapla
melons
meltwater
Mentha arvensis
mercury
meristem tips
metabolic sink
metabolism
metabolites
metal ions
metal tolerance
meteorological factors
meters
methazole
methodology
metolachlor
metolachlor .
metribuzin
metsulfuron
michigan
micro irrigation
microbial activities
microbial degradation
microbial inoculant
microirrigation
micronutrient
micronutrients
microorganisms
micropropagation
microtus
microtus pennsylvanicus
Migratrol
mildews
milk carton
mineral absorption
mineral content
mineral deficiencies
mineral fertilizers
mineral nutrition
mineral nutrition.
mineral phases
mineral soils
mineral uptake

mineralization
mineralogy
minerals
minituber production
minnesota
minor use
miscanthus
miscanthus oligostachyus
miscanthus sinensis
mist
mist propagation
miticide
mixtures
mode of action
models
modification
modifying pH
moisture
moisture content
moisture meters
molecular weight
MON 15151
monitoring
Monocots
morphology
mortality
mountain areas
mountain soils
mountains
movement
movement in soil
mowing
mucor
mulch
mulches
mulching
multibag
multiple applications
multipurpose trees
mutants
mycorrhize
myths
NAA
napropamide
napropanide
naptalam
narcissus
native plant
native plants
natural enemies
nebraska
necrosis
nectarines
needle fascicle
nematicides
nematoda
nematode control
nematology
Nerium oleander
netting
neutron probe
neutron probes
new england states of usa
New Hampshire
New Hampshire.
New World
new york
New Zealand
New Zealand.
newspapers
NFT
nickel
Nicotiana tabacum
nicotiana-tabacum. promoters-. histones-. dna-binding-proteins. binding-. transcription-factors. phosphorylation-. cell-cycle. transcription-. gene-expression. genetic-regulation. binding-sites.
nitralin
nitrapyrin
nitrate
nitrate nitrogen
nitrate fertilizers
nitrate nitrogen
nitrate nitrogen.
nitrates
nitric acid
nitrification
nitrites
nitrogen
nitrogen fertilizers
nitrogen content
nitrogen content.
nitrogen fertilization
nitrogen fertilizers
nitrogen fixation
nitrogen mineralization
nitrogen phosphorus fertilizers
nitrophenyl ether herbicides
no tillage
nodal segments
nodulation
NOMULE
nonclay minerals
nondestructive testing
nontarget effects
norea
norflurazon
North Carolina
North Carolina.
North Dakota.
nova scotia
nozzles
npk fertilizers
npk-fertilizers placement
Nu-pots
nucleotide sequences
nurseries
Nurseries Horticulture
nurseries horticulture United States costs
nurseries horticulture United States management
nursery
nursery corps
nursery crop production
nursery crops
nursery design
nursery establishment
nursery management
nursery management.
nursery mangement
nursery operation
nursery production
nursery setup
nursery soils
nursery stock
nut crops
nutricote
nutrient analysis
nutrient availability
nutrient content
nutrient contents
nutrient contents of plants
nutrient deficiencies
nutrient excesses
nutrient film techniques
nutrient management
nutrient monitoring
nutrient nutrient interactions
nutrient nutrient interactions.
nutrient ratios
nutrient removal by plants
nutrient requirements
nutrient retention
nutrient solutions
nutrient sources
nutrient system
nutrient transport
nutrient transport. growth
nutrient uptake

nutrients
nutrition
nutrition research
nutritional state
nuts
nylon
Nyssa sylvatica
oats
ocadiazon
ocyfluorfen
offshoots
OH II
OH-2
ohio
oils
oklahoma
olea europaea
Olives
ontario
operating costs
ophiopogon
Opuntia
Opuntia amyclaea
oranges
orchard management
orchard soils
orchards
oregon
organic by-product
organic fertilizers
organic horizons
organic matter content
organic soils
organogenesis
ornamental
ornamental bulbs
ornamental conifers
ornamental diseases and pests control
ornamental foliage plants
ornamental herbaceous plants
ornamental nursery stock
ornamental plants
ornamental plants.
ornamental plants;
ornamental trees
ornamental value
ornamental woody plants
ornamental woody plants.
ornamental woody-plants
ornamentals
Ornithogalum umbellatum
oryfluorfen
Oryza sativa
oryzalin
osmocote
osmotic pretreatment
over-wintering
overhead irrigation
overhead sprayers
oversowing
overwinter
overwinter storage
overwintering
oxadiazon
oxadiazon ; simazine ; usage ; mixtures ; crops ; economics ; woody plants; container grown plants; weed control; cultural methods; containers ; ornamental plants; ornamental woody plants
Oxalis stricta
oxidation
oxidiazon
oxidoreductases
oxydiazon
oxyflourfen
oxyfluorfen
oxyfluorfen-2G
oxygen
ozone
paclobutrazol
paeonia
paints
Panicum dichotomiflorum
panicum virgatum
paper
paper mill waste
paper pellets
paper pot
paraquat
Parkinsonia aculeata
partially acidulated rock phosphate
particle size
particle size distribution
PATC ornamental
pathogens
Patmore ash
PDP (US)
peach
peaches
pearl millet
pears
peat
peat soils
pecan
pecans
pelargonium
Pelargonium hortorum
pendemethalin
pendimethalin
pendimethlin
penetration
Penicillium
Penicillium citrinum
pennisetum alopecuroides
Penstemon
Peperomia obtusifolia
Peperomia obtusifolia.
Peperomia serpens
perched water table
perennial habit
perennial ryegrass
perennial weeds
perennials
perennials-. crop-production. greenhouse-culture. flowering-. regulation-. forcing-. timing-. literature-reviews.
perlite
permanent grasslands
persea americana
persistence
pest
pest control
pest control, alternative
pest management
pest resistance
pest resitance
pesticide
pesticide application
Pesticide Data Program (US)
pesticide handbook
pesticide persistence
pesticide residues
pesticide-action
pesticides
pesticides Ohio application study and teaching
pests
petiol
petiole
petiole analysis
petiole analysis
petioles
petunia
Petunia hybrida
PGR
ph
Pharbitis hederacea
phaseolus vulgaris
Phellodendron sachalinense

phenology
pheromone traps
Philadelphus virginalis
phisological state
phloem
phlox
phoracantha semipunctata
phosphates
phosphoric acid
phosphorine
phosphorus
phosphorus fertilizers
phosphorus fertilizers;
phosphorylation
Photinia fraseri
photoautotrophic
photocixotrophic
photoinhibition
photolysis
photoperiod
photoperiodism
photosynthate production
photosynthates
photosynthesis
photosystem II
Phragmidium
phylogeny
physical control
physical properties
physical property
physico chemical properties
physico chemical properties of soil
physicochemical properties
physiological disorder
physiological disorders
physiology
Physostegia
Physostegia virginiana
phytochrome
Phytophthora syringae
phytotoxicity
phytotoxicity .
Picea abies
Picea engelmannii
Picea glauca
Picea glauca cv. Conica
Picea mariana
Picea sitchensis
pinch
pinching
pine bark
pine bark.
pine bark. growth
pine tree chips.
pines
pines arable soils
Pinus
pinus banksiana
Pinus contorta
Pinus echinata
Pinus eldarica
Pinus elliottii
Pinus glauca
Pinus monticola
Pinus mugo
Pinus palustris
Pinus palustris Mill.
pinus ponderosa
Pinus radiata
Pinus resinosa
Pinus strobus
Pinus sylvestris
Pinus taeda
Pinus thunbergi
pip
Pisolithus tinctorius
Pistacia chinensis
Pisum sativum
Pittosporum tobira
placement
planning
plant
plant morphology
plant analysis
plant competition
plant composition
plant composition.
plant damage
plant density
plant description
plant descriptions
plant development
plant disease control
plant diseases
plant disorders
plant establishment
plant genetic resources
plant growth regulator
plant growth regulators
plant health management
plant height
plant height.
plant introduction
plant morphology
plant nematology
plant nutrition
plant parasitic nematodes
plant pathogenic bacteria
plant pathogenic fungi
plant pathogens
plant pathology
plant pests
plant physiology
plant propagation
plant protection.
plant selection
plant tissues
plant water relations
plant-analysis
plant-containers
plant-metabolism
plant-protection
Plantae
plantations
planting
planting date
planting depth
planting media
planting methods
planting stock
planting stock;
planting stocks
plants
plasma emission spectroscopy
plastic containers
plastic film
plastic foam
plastic-film
Platanus occidentalis
Platycodon grandiflorus
ploidy
plowing
plug production
plums
Poa pratensis
poinsettia
poinsettias
pointsettia
poland
polarity
pollinators
polluted soils
pollution
pollution by agriculture
pollution prevention
polyethylene
polyethylene film
Polygonum pensylvanicum
polymers
polypropylene tube treeshelters
polypropylenes
Polystichum

ponderosa pine
ponds
poplar
poppenate-methyl
population density
population density.
population dynamics
Populus
Populus balsamifera
Populus maximowiczii
Populus tremula
Populus tremuloides
Populus wilsocarpa
porcelain berry
porosity
position
post harvest physiology
post-harvest
postharvest losses
postharvest physiology
postharvest treatment
pot culture
pot plants
pot-in-pot
potassium
potassium fertilizers
potassium nitrate
potato
potatoes
pots
potting
poultry manure
pour through method
prairie
pre-emergence herbicide
pre-harvest
precipitation
predation
predators
prediction
preemergence
preparation
preplanting treatment
pressure transducers
pretreatment
prevention
private forestry
probes
procedures
processing
prodiamine
product development
production
production costs
production possibilities
production system
production systems
production sytem
productivity
products
profitability
profluralin
promoters
pronamide
propachlor
propagation
propagation materials
propagation structure
propagation, vegetative
propazine
properties
propyzamide
Prosopis alba
prostrate spurge
protected cultivation
protection
protein synthesis
proteins
provenance trials
pruning
pruning paint
Prunus
prunus avium
Prunus domestica
Prunus dulcis
prunus mume
prunus persica
Prunus spp.
Prunus x incamp
Pseudotsuga menziesii
ptotato shoot growth, tuber yeild
public health
pulse irrigation
Pyracantha
pyridine herbicides
Pyrus calleryana
Pyrus communis
Pyrus pyrifolia
QTL
quality
quantitative analysis
quantitative traits
quatitative trait loci
Quercus
quercus acutissima
quercus alba
Quercus coccinea
quercus falcata var. pagodifolia
Quercus ilex
Quercus macrocarpa
Quercus palustris
Quercus phellos
Quercus rubra
Quercus shumardi
Quercus shumardii
quercus stellata
Quercus virginiana
quizalofop
quonset
Radermachera sinica
radioactive tracers
radishes
rain
random amplified polymorphic dna
Raphanus sativus
rapid methods
ratios
reclamation
recorders
recording
recycling
red light
red pine
Red Rocket
redox potential
reflectance
reflectometry
reflectrometry
regeneration
regenerative ability
registration
regression analysis
regrowth
regulation
relationships
release
remote sensing
reproduction
requirements
research
research institutes
research projects
research report
residual effects
residues
resistance
responses
responses]
retail
retention
retention ponds
return bloom

reviews
rhizobium
Rhizobium leguminosarum
rhizomes
rhizosphere
rhododendron
Rhododendron indicum
Rhododendron obtusum
Rhododendron obtusum 'Rosebud'
rhododendron simsii
rhyacionia frustrana
ribosomal DNA
rice
rice hulls
rice husks
ridging
ringing
ripening
risk
rivers
rock phosphate
rockwool
rodenticides
Ronstar
root
root bag
root ball
root circling
root control
root coverage
root crops
root crops;
root damage
root deformation
root development
root escape
root hardiness
root length
root pruning
root shoot ratio
root shoot ratio.
root system
root systems
root systems.
root tips
root tips.
root zone
root zone flux
root zone temperature
root-collar diameter
rootballs
rooted cuttings
rooting
rooting capacity
rooting .
rooting capacity
rooting depth
rooting hormones
rooting media
rooting medium
rootmaker
rootrainer
roots
roots media
rootstock scion relationships
rosa
Rosaceae
rose
rosemary
roses
Rosmarinus
rotations
row spacing
RSW0411
rubidium
rubus idaeus
Rubus spp.
rudbeckia
Rudbeckia Fulgida
Rudbeckia hirta
runners
runoff
runoff water
rural areas
Rutaceae
rye
safening agent
safety
Saintpaulia
saline sodic soils
salinity
saliva
Salix babylonica
salt
salts
salts in soil
salvia
Salvia superba
sample pretreatment
samplers
sampling
sampling protocols
sampling techniques
sand
sand capillary beds
sandy loam soils
sandy soils
sap
saskatchewan
saskatoon
saturated conditions
saturated hydraulic conductivity
saturation extract
scarification
schefflera actinophylla
Scotch pine
scotland
screening
sea-buckthorn
seasonal fluctuations
seasonal fluctuations
seasonal variation
seasons
seaweed products
Secale cereale
sediment
sediment .
seed age
seed dormancy
seed germination
seed production
seed propagation
seed set
seed stratification
seed treatment
seed weight
seedbed
seedbeds
seedling
seedling culture
seedling emergence
seedling growth
seedling growth.
seedling stage
seedlings
seeds
selective screening
Senecio vulgaris
senescence
sensors
Sequoia sempervirens
set
Setaria faberi
sethoxydim
sewage sludge
sexual reproduction
shade plants
shade tolerant
shade trees
shading
shape
shelterbelt

shelterbelts
shoot cuttings
shoot development
shoot multiplication
shoot tips
shoots
shoots .
shows
shrubs
Shumard oak
silica
silicon
silky dogwood
silt loam soils
silty soils
silver
simazine
simulation models
Sinningia speciosa
siphoninus phillyreae
site factors
site index
site preparation
size
Slash pine Fertilizers
Slash pine Seedlings
slow release
slow release fertilizer
slow release fertilizers
slow-release herbicide
small fruits
small-fruits
snake oil
sod
sodium
software
soil
soil -temperature
soil acidity
soil acidulants
soil additive
soil alkalinity
soil amendment
soil amendments
soil analysis
soil bacteria
soil based versus soilless culture
soil chemistry
soil conservation
soil contamination
soil deficiencies
soil density
soil depth
soil drench
soil drenches
soil enzymes
soil erosion
soil extracts
soil fertility
soil flora
soil fumigation
soil fungi
soil improvement
soil inoculation
soil management
soil moisture
soil organic matter
soil parent materials
soil ph
soil ph.
soil physical properties
soil physics
soil pollution
soil probe
soil profiles
soil reclamation
soil salinity
soil separates
soil solarization
soil solution
soil stabilization
soil structure
soil temperature
soil test values
soil testing
soil tests
soil texture
soil toxicity
soil treatment
soil treatment.
soil types
soil types chemical
soil types cultural
soil types ecological
soil types genetic
soil types textural
soil types, chemical
soil types, genetic
soil water
soil water content
soil water potential
soil water regimes
soil-analysis
soil-fertility
soil-treatment
soil-water-movement
soilless culture
soilless media
soils
solanum
Solanum melongena
Solanum tuberosum
solarization
solonetz
solubility
soluble salts
soluble solids
solutions
somatic embryogenesis
sorbitol
Sorbus decora
sorghum
Sorghum bicolor
Sorghum sudanense
sorption
source sink relations
sources
South Africa
south australia
south carolina
south dakota
sowing
sowing rates
soyabeans
spacing
Spathiphyllum
spatial distribution
spatial distribution.
spatial variation
speciation
species
species differences
species differences.
specific ion electrodes
spectral quality
Spermatophyta
Spermatophytes
Sphaerotheca pannosa
spinout
Spiraea nipponica
split dressings
splitting
spray drift
spraying
sprays
spring
spring frost
sprinkler irrigation
spurs
stakeout
stand establishment
starch

starter dressings
statisitics
statistical data
Stellaria media
stems
stimulant plants
stimulation
stock plants
stocks
Stokesia laevis
stomata
stomatal movement.
stomatal resistance
stone fruits
stooling
storage
storage quality
strains
straw
straw mulches
strawberries
street trees
stress
stress response
structure activity relationships
styrene
suberization
subsoil
substrate
substrates
subsurface drainage
subsurface drip
subsurface irrigation
subsurface runoff
subtropical crops
subtropical fruits
suckering
suckers
sucrose
sugar
sugar crops
sugarcane
sugars
sulfate
sulfate reducing bacteria
sulfate sulfur
sulfates
sulfides
sulfur
sulfur dioxide
sulfur fertilizers
sulfur foam
sulfuric acid
summer
sunflowers
superphosphate
superphosphate, single
supplemental organic material
suppression
surface area
surface irrigation
surface treatment
surface water
surface-tension
surfactants
survey
surveying
survival
susceptibility
swamp soils
swamps
sweden
sweetcorn
Swietenia mahagoni
symptoms
synergism
syringa
system
systems
Tabebuia .
tableting
tagetes
Tagetes erecta
Tagetes erecta L.
Tagetes patula.
Tanacetum coccineum
tangelos
tangors
taxodium distichum
Taxus
Taxus cuspidata
Taxus media
Taxus media cv. Browni
TDR
tea
teaching materials
techniques
teepol
temperate fruits
temperate Zones
temperature
temporal variation
tensiometer
tensiometers
terbacil
test plants
test procedure
testa chipping
testing
tests
tetcyclacis
tetrazolium
Texas
textiles
Thelypteris
Theobroma cacao
thermal infrared imagery
thermoblanket
thiamin
thidiazuron
thinning
thiobacillus
thiobacillus thioparus
thiocyanates
thiram
thuja
Thuja occidentalis
Thuja occidentalis cv. Globosa
Thuja plicata
thylakoids
Thymus
TIBA
tile drainage
Tilia mongolica
tillage
tillers
time
time domain reflectrometry
time of day
timing
tissue analysis
tissue culture
tissue cultures
tissue extracts
tissues
titratable acidity
tolerance
tolerances
tomatoes
tools
top dressings
topdressing
topical application.
toxic substances
toxicity
trace element deficiencies
trace element fertilizers
trace elements
tracers
Trachycarpus fortunei.
trademark
training

trans zeatin riboside
transcription
transcription factors
transformation
transgenic plants
translocation
transpiration
transplant
transplant shock
transplant survival
transplanting
transplanting .
transplanting success
transplants
transport processes
transport processes in soil systems
transporting quality
trapping
traps
trays
TRE Nursery Program
treatment
tree fruits
tree guards
tree seedling
tree seedlings
tree shelter
tree stump removal
trees
treeshelter
triazines
trickle irrigation
trifluralin
trifolium
Trifolium incarnatum
Trifolium pratense
Trifoiium repens
trillium
trimming
triple superphosphate
triplesuperphosphate
Triticum aestivum
tropical crops
tropical fruits
trunk
trunks
Tsuga heterophy: a
Ttrifolium incarnatum
Ttrifolium subterraneum
tubers
tubex
tulips
turf
turf pest control
tween-80
types
Ulmus
Ulmus alata
ultisols
umbelliferae
unclassified herbicides
uniconazole
united kingdom
upcanning
upland areas
uptake
uptake mechanisms
urban areas
urban forestry
urban sites
urea
urea ammonium nitrate
urea fertilizers
urea phosphates
urea spray
urea sprays
urease
URMULE
usa
usage
USB-3153
usda
use efficiency
ussr
utah
utilization
uttar pradesh
Vaccinium
Vaccinium ashei
Vaccinium corymbosum
valve
vapour pressure deficit
variable costs
variation
variations
variegated plants
varietal reactions
varieties
Vascular plants
vascular system.
vegetable growing
vegetable legumes
vegetables
vegetation
vegetation management
vegetation types
vegetative period
vegetative propagation
vegetative propagation.
verbena
vermiculite
Vermont
vernalization
veronica
Veronica repens
vertebrate pests
vertical movement
viability
viburnum
Viburnum plicatum
Viburnum spp.
Viburnum trilobum
Vicia grandiflora
Vicia villosa
Vigna unguiculata
vigor
vinca
vines
virginia
vitis
Vitis vinifera
volatilization
volume
washington
waste usage
waste utilization
waste waters
wastes
water
water absorbant
water absorbants
water absorption
water application efficiency
water availability
water availability;
water composition and quality
water conservation
water contamination
water content
water deficit
water distribution
water efficiency
water holding capacity
water intake
water management
water pollution
water potential
water quality
water quality management
water relations
water requirements
water retension curve

water reuse
water reuse and treatment
water spreading
water statistics
water stress
water temperature
water uptake
water use
water use efficiency
waterlogging
watersheds
weather station
weathering
weed
weed classification
weed control
weed control, alternative
weed control, nonchemical
weed control, organic
weed dispersal
weed identification
weed interference
weed seeds
weed suppression
weeding
weeds
weight
wells
western Australia
wetter
wetters
wetting agent
wheat
width
wilting point
wind
wind erosion
winter
winter damage
winter hardiness
winter injury
winter storage
winter survival
wire
wonder product
wood chips
wood ornamental
wood waste
woody ornamental
woody ornamental plants
woody ornamentals
woody plants
wound dressings
wounds
wrapping
x-radiation
xylem
xylem sap
xylem water potential
yards
yield components
yield increases
yield losses
yield response functions
yields
Yugoslavia
Zea mays
zea-mays
zeatin
zeolites
zinc
zinc fertilizers
zinnia

The Prairie Nursery Literature Collection – ID number, Citation and Abstract

(1) McDonald, S. E., R. W. Tinus, et al. (1984). Effect of CuCo3 [cupric carbonate] container wall treatment and mycorrhizae fungi inoculation of growing medium on pine seedling growth and root development [Ponderosa pine, Pinus ponderosa, lodgepole pine, Pinus contorta]. Journal of Environmental Horticulture 2(1): 5-8.
Coating the inside surfaces of containers with cupric carbonate ($CuCO_3$) stopped lateral root growth of ponderosa pine (Pinus poderosa Laws.) and lodgepole pine (Pinus contorta Dougl.) at the container wall. Subsequent higher order laterals proliferated and were similarly arrested. The $CuCO_3$ treatement was compatible with the inoculation of the growing medium with the mycorrhizae fungi Pisolithus tinctorius (Pers.) Coker and Couch and Suillus granulatus (L. ex. Fr.) O. Kuntze. Combined inhibitor -- inoculum treatments resulted in pine seedlings that were bigger, had more lateral roots, and greater mycorrhizal infection rates than untreated seedlings

(2) Pilat, C. W. (1972). The role of foliar feeding in agriculture. Agrichemical Age 15(8): 7-8.

(3) Foy, C. D., G. Montenegro, et al. (1953). Foliar feeding of corn with urea nitrogen. Soil Science Society Proceedings 17(4): 387-390.

(4) Nowosielski, O., W. Dziennik, et al. (1988). A biological basis for the efficiency of plant protecting foliar fertilizers in vegetable production. Acta Horticulturae(222): 105-116.

(5) Shawa, A. Y. (1982). Response of 'McFarlin' cranberry to nitrogen sprays. HortScience 17(6): 949-950.
Two nitrogen formulations, urea and ammonium sulfate, were applied as aqueous sprays to 'McFarlin' cranberry (Vaccinium macrocarpon, Ait.) vines at the rate of 0, 1.12, 2.24, 3.36, 4.48 and 5.6 kg N/ha at 5, 50, and 80% bloom. Urea appliead 3 times during bloom at 4.48 kg N/ha increased yield. The nitrogen treatments had no significant effect on soluble solids, pH, or fruit breakdown.

(6) Singh, H. K., B. P. Singh, et al. (1981). Effect of foliar feeding of various chemicals on physico-chemical quality of guava fruits. Haryana Agriculture University Journal of Research 11(3): 411-414.

(7) Rieckenberg, R. (1992). Foliar feeding supplies only micronutrients successfully. Agfocus(April): 16.

(8) Heckman, J. R. (1994). Evergreens vary in sensitivity to foliage burn from over application of foliar fertilizer. Am nurserym 179(6): 89-90.

(9) Edmisten, K. L., C. W. Wood, et al. (1994). Effects of early-season foliar fertilization on cotton growth, yield, and nutrient concentration. Journal of Plant Nutrition 17(4): 683-692.
Many producers are using foliar fertilizers on seedling cotton (Gossypium hirsutum L) with the intent of promoting early vigor and increasing yields. However, the hypothesis that foliar feeding young cotton increases seedling vigor and yield has not been rigorously tested. We conducted 5 studies during 1990 to 1992 to investigate the value of one, two or three foliar applications of 12-48-8 fertilizer to seedling cotton. Two studies also included foliar-applied urea. Plant height and whole-plant phosphorous (P) and nitrogen (N) were determined two weeks after each application in two studies. Yield and P and N concentrations were not influenced by foliar fertilizers in any study. Seedling height was not influenced by applications of 12-48-8. A slight early-season height advantage was observed with foliar-applied urea at one location. Our results suggest that application of foliar N and P fertilizers to seedling cotton has little agronomic value.

(10) M'Itungo, A. M. and H. A. M. v. d. Vossen (1981). Nutrient requirements of coffee seedlings in polybag nurseries: the effect of foliar feeds in relation to type of potting mixture. Kenya Coffee 45(54): 181-187.
Results of three nursery experiments have indicated that with a potting mixture of topsoil, sand, well matured farm yard manure and some superphosphate, healthy and transplantable coffee seedlings can be produced within 12 months without additional topdressing organic and inorganic fertilizers or foliar feeds. With less ideal potting mixutres or without f.y.m., foliar feed applications do imporve growth of coffee seedlings. Details of an inexpensive home-made foliar feed are presented

(11) Mohandass, S. and V. Sampath (1983). Efficacy of foliar feeding of nitrogen on foliage and oil yield in geranium (Pelargonium graveolens L'. Her). Indian Perfumer 27(1): 9-11.
The herbage and oil yields of geranium were increased when N was applied through foliage. Application of 30 kg N/ha (half as basal and half as foliar spray of urea in two split doses at 45 and 90 days after basal application) increased the herbage and oil yield by 46.9 and 140.1 per cent, respectively, as compared to control.

(12) Montville, M. E., D. L. Wenny, et al. (1996). Foliar fertilization during bud initiation improves container-grown ponderosa pine seedling viability. Western Journal of Applied Forestry 11(4): 114-119.
Our objective was to determine if avoiding nutrient stress during bud initiation of ponderosa pine (Pinus ponderosa var. ponderosa) grown in a container nursery would enhance seedling viability. Nitrogen stress was avoided by applying foliar fertilizer at rates between 324 and 972 ppm N to greenhouse-grown seedlings. Foliar fertilization maintained higher seedling nitrogen levels and increased root collar diameter by 45%. Height was slightly increased, cold-hardiness slightly reduced, and root growth potential unaffected by foliar fertilizer applications. Nursery managers can improve seedling viability by adding foliar fertilizer applications to their growing regimes.

(13) Melville, D. R., A. M. Pavloff, et al. (1976). Foliar feeding and petiole analysis to determine optimum nutrient requirement of the cotton plant. Annual Research Report, Red River Valley Agricultural Experiment Station: 80-93.

(14) Rajeswara Rao, G. (1983). Influence of foliar fertilization on tolerance of plants to environmental stress. Proceedings of the National Symposium on Advancing Frontiers of Plant Sciences: 69-70.

(15) Grewal, G. P. S., A. S. Dhatt, et al. (1991). Foliar feeding of zinc and iron in peach. Proceedings of an International Seminar on New Frontiers in Horticulture: Horticulture -- New Technologies and Applications, Bangalore, India: 55-57.

(16) Reed, D. W. and H. B. Tukey, Jr. (1987). Factors affecting foliar absorption of nutrients by selected landscape and herbaceous plants. Journal of Environmental Horticulture 5(2): 72-76.
Plants and solution properties affecting the absorption of double-labled ^{86}Rb ^{33}P-phosphate, pH 7.2, by chrysanthemum leaves

were studied. Leaf age did not affect absorption greatly. Optimum concentration for maximum total absorption and efficiency of absorption of both Rb and P without leaf burn was 20-30 mM Rb phosphate. Urea and several structurally related compounds (acetamide, propionamide and Rb acetate) decreased Rb and P absorption due to formation of salt deposits. Of 18 commercially available surfactants tested at 0.1%, only one significantly increased P absorption and all significantly decreased Rb absorption; many were phytotoxic. Of a variety of 20 different herbaceous ornamental and woody landscape species tested for their efficiency of absorption, P absorption ranged from 0.2 - 39% and Rb absorption ranged from 0.2 - 42%; surfactants generally increased the absorption of P and Rb for those species with waxy, pubescent or otherwise hard-to-wet leaves.

(17) Reickenberg, R. L. and M. P. Pritts (1996). Dynamics of nutrient uptake from foliar fertilizers in red raspberry (Rubus idaeus L.). Journal for the American Society of Horticulture Science 121(1): 158-163.
The dynamics of nutrient uptake from foliar applied 15N-urea and Rb (a K analog) were quantified in red raspberries. Both N and Rb in an aqueous solution were absorbed rapidly into the leaf and transported throughout the plant. In the greenhouse, about half of the urea and a third of the Rb were absorbed within 32 hours of application. The addition of a surfactant to the foliar solution reduced uptake, while solution pH, time of application and leaf age had little effect. The lower leaf surface exhibited a faster rate of absorption than the upper surface, but the difference was not large. In the field, some foliar N appeared to have been washed off leaves and taken up by the root system; however, none of the foliar applications affected plant growth. We conclude that significant uptake of foliar applied N and K occurs in raspberry, but the absolute amount delivered through a single foliar application is small. The percentage of total plant nutrient supplied through a foliar application is reduced to <5% over time as the plant grows, so multiple applications would be required to maintain levels significantly higher than would exist through root uptake alone.

(18) Minotti, P. L. (1993). Foliar feeding: will it improve your vegetable crop. St Lawrence County Agriculture News 77(6): 4.

(19) Long, D. W., J. B. Graves, et al. (1992). Physical incompatibility of insecticides in foliar fertilizer. Louisiana Agriculture 35(5): 6-8.

(20) Cimato, A., M. Marranci, et al. (1990). The use of foliar fertilization to modify sinks competition and to increase yield in olive (Olea Europaea cv Frantoio). Acta Horticulturae(286): 175-178.
The competition between vegetative and reproductive activities strongly controls the final yield of fruit trees. This phenomenon is of considerable interest in olive culture showing that the olive plant has a natrually reduced reproductive activity. Two years experiments were carried out on the olive cv Frantoio to study the action of foliar nitrogen fertilization on vegetative and reproductive growth. Vegetative and flowering parameters were measured at different times of the growth season; nitrogen status of the plant was also evaluated. The foliar fertilization affected sink competition and improved the yield as a combined result of an increased fruit set and reduced fruit drop.

(21) Alexander, A. and M. Schroeder (1987). Modern trends in foliar fertilization. Journal of Plant Nutrition 10(9/16): 1391-1399.
Foliar fertilization is attracting renewed interest as an efficient and economic way of supplimenting nutrient supply. The present state of foliar fertilization is illustrated, and its advantages and disadvantages are discussed. Encouraging results demonstrating increased pesticide efficiency, when combined with foliar fertilizer formulations are presented and preliminary practical results of yields maintained by supplementary nutrient spraying, despite reductions in recommeded soil fertilization levels are also shown. The great potential of foliar fertilization as a means of alleviating soil and water pollution is stressed.

(22) Leece, D. R. and A. L. Kenworthy (1971). Effect of potassium nitrate foliar sprays on leaf nitrogen concentration and growth of peach trees. HortScience 6(2): 171-173.
Foliar sprays of KNO_3 were applied to young, N-deficient peach trees in 2 experiments over a 2-year period. Urea was compared with KNO_3 in 1 year. Neither autumn nor spring applications of KNO_3 or urea increased leaf N concn or tree growth significantly, although in 1 year, the sprays delayed the onset of leaf senescence. By comparison, an autumn soil application of NH_4NO_3 significantly increased leaf N conc, terminal shoot growth, and trunk circumference

(23) Anon. (1980). Foliar Feeding -- Filling the gaps in your fertilization program. California Grower and Rancher 35(8): 4, 8, 13.

(24) Fritz, A. (1978). Foliar fertilization--a technique for improved crop production. Acta Hort(84): 43-56.
It was found that plants can also make use of nutrients, applied to the foliage. Practical use the plant's ability to take up nutirents viea the leaves is made by application of foliar fertilizers. The process of nutrient uptake via leaves is explained.
The optimum nutrient composition of leaves has been studied with leaf analysis in many crops.
Foliar fertilization should be physiologically balanced containing all main and secondary plant nutrients and essential trace elements.
In line with the development pattern of each individual crop, optimum application periods for foliar fertilization can be identified, mostly being identical with periods of highest production of dry matter. Repeated application of small units of foliar fertilizers are stimulating plant metabolism and increased nutrient uptake via the roots can be observed.
Total production as well as its quality is improved by foliar fertilization. The stimulating effect of foliar fertilization depends on sound basic fertilizer rates including the supply of trace elements either via root or via the foliage. Foliar fertilization thus being a supplement to adequate fertilizer application to the soil, not a substitute. Trace element fertilization via the leavs leads to special economical results avoiding high losses of trace elements in the soil (immobilization).
Ample examples of trial results of foliar fertilizer application are given for various crops

(25) Weinbaum, S. A. (1978). Feasibility of satisfying total nitrogen requirement of non-bearing prune trees with foliar nitrate. HortScience 13(1 pt 1): 52-53.
The feasibiltiy of supplying the total N requirements of young, non-bearing 'French' prune (Prunus domsetica L.) trees with foliar-applied NO_3^- was assessed based on the amount of N absorbed following foliar application of 15N-enriched KNO_3 and the seasonal N requirement as estimated by the total N accumulated over the growing season. Based on these data, 2-year-old prune trees would require more than 140 applications of 1.2% KNO_3 per

year to maintain normal growth if foliar NO_3^- was the only N source.

(26) Schupp, J. R. (1993). Orchard mineral nutrition: ground-applied vs. foliar-applied fertilizers. Fruit Notes 58(2): 20-23.

(27) Piatkowski, M. G., K. Dronka, et al. (1990). Effect of fertilization of two apple cultivars with macro- and microelements. Acta Horticulturae(274): 383-386.
The experiment was set up in spring 1981 at the Experimental Station in Dabrowice near Skierniewice, Poland, on sandy loam, grey-brown podsolic soil, poor in organic matter and Mg, showing pH(KCl) = 5.6, on Antonovka seedlings with dwarfing interstem B 9. Standard mineral fertilization (N-100, P2O5-50 and K2O-100 kg per ha) resulted in an increase of yield of both cultivars. Lime had no positive effect on yield but improved fruit coloration of Empire apples. Mulching with FYM increased yield of both cultivars and in case of cv Empire it gave better results than mineral fertilization. Entirely foliar fertilization with Florovit had no effect on yield of Empire and slighty decreased yield of MacSpur E. Calcium chloride sprays caused a decrease of yields while foliar applications of calcium phosphate increased the yield of Empire trees. After the severe winter 1986/87 fertilized trees yielded much better than the unfertilized ones; a positive effect of calcuim phosphate sprays was also noted.

(28) Schultz, R. P. (1968). Soil or foliar fertilization of well-drained and flooded slash pine seedlings.

(29) Rosecrance, R. C., R. S. Johnson, et al. (1998). Foliar uptake of urea-N by nectarine leaves: a reassessment. HortScience 33(1): 158.

(30) Schnurr, J. P., Z. M. Cheng, et al. (1996). Effects of plant growth regulators on sturdiness of jack pine seedlings. Journal of Environmental Horticulture 14(4): 228-230.
Seven growth regulators (ancymidol, 6-benzylaminopurine, ethephon, flurprimidol, mefluidide, paclobutrazol, and uniconizole) at various concentrations were studied for their effects on sturdiness of greenhouse grown seedlings of jack pine (Pinus banksiana Lamb.), measured by a single parameter, growth modification index. All growth regulators at certain concetrations were effective in reducing plant height but none increased stem caliper. Several growth regulators increased shoot-to-root dry weight ratio. Benzylaminopurine greatly modified growth characteristics and resulted in deformed seedlings. Uniconizole was most promising for producing sturdier seedlings of jack pine.

(31) Svenson, S. E. (1991). Rooting and lateral shoot elongation of Verbena following benzylaminopurine application. HortScience 26(4): 391-392.
Rooting and growth of Verbena cuttings (Verbena Xhybrida Voss) were measured to determine response to foliar-applied benzylaminopurine (BA). There was no rooting response to BA application when visible nodal roots were present at the base of the cutting. There was no response to 30, 100, or 300 mg BA/liter applied to the foliage 48 or 96 hours after excision from the stock plant. Rooting-zone dry mass, total cutting dry mass, and number of roots were increased by 30 mg BA/liter applied immediately after excision when there were no visible nodal roots at the base of the cuttings. Foliar application of BA at 10 or 30 mg.liter-1 increased lateral bud elongation of subsequently rooted shoots by 20% and 49%, respectively. Application of BA during cutting propagation to enhance subsequent lateral bud elongation does not appear to inhibit root e in Verbena stem cuttings.

(32) Garner, J. M., G. J. Keever, et al. (1997). Benzyladenine-induced offset formation in hosta dependent on cultivar. HortScience 32(1): 91-93.
A foliar spray of 0, 1250, 2500, or 3750 mg benzyladenine (BA)/L was applied to 10 Hosta Tratt. (Funkia K. Spreng; Niobe Salisb.) cultivars. Response to BA treatment was cultivar dependent, with BA promoting offset formation in half of the cultivars. Compared to the control, increase in offsets produced by cultivars treated with 3750 mg BA/L ranged from 116% in 'Francee' to 3500% in 'Francis Williams' at 30 days after treatment (DAT) and from 150% in 'Royal Standard' to 2250% in 'Francis Williams' at 60 DAT. Offset stage of development, as indicated by the number of unfurled leaves, was also cultivar- and BA-dependent. All cultivars treated with 3750 mg BA/L had an average of three or more unfurled leaves at 60 DAT, while among control plants, 40% of cultivars averaged fewer than three unfurled leaves. No phytotoxic symptoms were noted in any cultivar, and plant size was either increased or not affected by BA treatment.

(33) Wismer, P. T., J. T. A. Proctor, et al. (1995). Benzyladenine affects cell division and cell size during apple fruit thinning. [Erratum: Nov 1995, v. 120 (6), p. 1096.]. Journal for the American Society of Horticulture Science 120(5): 802-807.
Benzyladenine (BA), carbaryl (CB), daminozide (DM), and naphthaleneacetic acid (NAA) were applied postbloom as fruitlet thinning agents to mature 'Empire' apple (Malus domestica Borkh.) trees. BA, NAA, and CB reduced fruit set and yield per tree, and increased fruit size, percent dry weight, soluble solids content and return bloom. Fruit size was reduced, return bloom, length:diameter ratio and flesh firmness were increased, and fruit set and yield unaltered by DM. Although fruit set and yield were similar for BA, NAA, and CB, BA treated fruit were larger, indicating that BA increased fruit size beyond the effect attributable to chemical thinning alone. BA increased the rate of cell layer formation in the fruit cortex, indicating that BA stimulated cortical cell division. NAA, CB and DM had no effect on cell division rate. Mean cortical cell diameter at harvest was increased by NAA and CB and reduced by DM. Cell diameter at harvest in BA-treated fruit was similar to the control. These data support the hypothesis that BA-induced fruit size increase in 'Empire' apple results from greater numbers of cells in the fruit cortex, whereas the fruit size increase due to NAA or CB is a consequence of larger cell size.

(34) Greene, D. W. and W. R. Autio (1990). Vegetative responses of apple trees following benzyladenine and growth regulator sprays. Journal for the American Society of Horticulture Science 115(3): 400-404.
Benzyladenine (BA) stimulated lateral branching on young apple (Malus domestica Borkh.) trees at concentrations as low as 100 mg.liter-1. BA reduced lateral shoot length indirectly through increased intershoot competition, whereas daminozide reduced lateral shoot growth as a direct effect of the chemical inhibition. Daminozide reduced the number of spurs that were induced by BA to grow into lateral shoots. BA reduced the size of terminal buds on spurs that were stimulated to grow into lateral shoots. When daminozide was included with BA, spur quality was increased, as determined by increased bud size. The positive effect of daminozide on BA-treated spurs was indirect, and other growth retardants used in combination with BA may be equally effective at improving spur quality. It may not be possible to stimulate lateral branching with BA on young trees just coming into production without causing an unacceptable amount of thinning. However, on bearing 'Empire' trees, lateral shoot growth was increased with BA while still achieving an appropriate level of thinning. In general, there was no advantage to applying BA in a split application.

(35) Malik, H. and D. D. Archbold (1992). Manipulating primocane architecture in thornless blackberry with uniconazole, GA3, and BA. HortScience 27(2): 116-118.
The potential for plant growth regulator (PGR) manipulation of 'Chester Thornless' blackberry (Rubus spp.) primocane growth was evaluated. PGR treatments included combinations of soil-applied uniconazole at 1, 5, 25, and 125 mg/plant and GA3, foliar-applied one or two times at 100 ppm 3 and 4 weeks after a 25-mg/plant uniconazole application. Also, GA3 and BA were applied at 100 ppm alone or in combination one, two, or three times. Increasing rates of uniconazole reduced primocane length, leaflet count, and leaf, cane, and root dry weights. GA3 applications reduced primocane length and increased branch elongation but failed to reverse the effects of uniconazole at 25 mg/plant, except those on branch length, leaflet count, and primocane dry weight. Only applications of BA + GA3 increased both branch production and elongation and dry weights of some component tissues, while BA alone generally had no effects.

(36) Keever, G. J., W. J. Foster, et al. (1993). Increasing 'Bradford' pear crotch angles and lateral shoot counts with benzyladenine or promalin sprays. HortScience 28(6): 678.

(37) Harkess, R. L. and R. E. Lyons (1994). Gibberellin- and cytokinin-induced growth and flowering responses in Rudbeckia hirta L. HortScience 29(3): 141-142.
BA and GA(4 + 7) were applied to vegetative, mature Rudbeckia hirta plants at the beginning of long days (LD). There were no synergistic effects, but BA inconsistently affected branching and had no effect on flowering. Floral initiation of the terminal inflorescence was promoted by GA(4 + 7), although axillary inflorescences were not. Increasing GA(4 + 7) levels decreased the time to terminal inflorescence anthesis. However, the interval between the terminal and second axillary inflorescence anthesis was increased. The net result was no significant effect on the time to second axillary inflorescence anthesis. Gibberellins may enhance the LD effect on the apical meristem of Rudbeckia, but axillary meristems, which initiate later, remained unaffected.

(38) Stiff, C. M. and A. A. Boe (1985). Effects of foliar-applied benzylaminopurine on fascicular bud development in mugo pine. HortScience 20(2): 285-287.
Fascicular bud development in mugo pine (Pinus mugo var. mughus Zeneri) was induced by foliar application of BAP. Maximum numbers of fascicular buds developed when BAP was applied at concentrations of either 225 or 450 mg/L, 6 times (at 5-day intervals) for 30 days. Following a cold-treatment, plants treated with these concentrations of BAP exhibited a dense, bushy form due to the outgrowth of the developed fascicular buds. Chemical name used: benzylaminopurine (BAP).

(39) Pasian, C. C. and D. K. Struve (1996). Painted containers: a new method for paclobutrazol application. HortScience 31(4): 655.

(40) Pasian, C. C. and D. K. Struve (1996). Paclobutrazol/paint mix on the inside surface of plug cells to control plug height. Ornamental Plants: Annual Report and Research Reviews(Special Circular 154): 66-69.

(41) Pasian, C. C. and D. K. Struve (1996). Paint/paclobutrazol mix on the inside surface of the rooting wedge cells to control pointsettia cutting height. Ornamental Plants: Annual Report and Research Reviews(Special Circular 157): ? (4 pp total).

(42) Blake, J. I. and D. B. South (1990). Effects of plant growth regulators on loblolly pine seedling development and field performance. 6th Biennial S. Silv. Res. Conf., Memphis, TN (October 30 - November 1, 1990): 101-107.
Four plant growth regulators (ancymidol, benzyladenine, ethrel, and flurprimidol) were compared with two top pruning treatments at a nursery near Byron, Georgia. Chemical applications in August were generally more effective in reducing growth than September applications. Among the growth regulators tested, only benzyladenine applied in August appeared to reduced height growth by 2.3 cm. A single top pruning in early August substantially increased average height growth to the point where average seedling heights in December were not reduced. The treatments were lifted in January and deep-planted in mid-March on an old-field near Auburn, AL. first year survival was excellent (>92%) despite the dry spring. None of the treatments were significantly different from the control in terms of survival or height growth in the field.

(43) Armitage, A. (1998). Hostas: Growing them faster. Greenhouse Grower(May): 130 - 131.

(44) Garner, J. M., G. J. Keever, et al. (1997). BA application promotes offset formation in Hosta cultivars. Journal of Environmental Horticulture 15(3): 119-122.
A foliar spray of 0, 1250, 2500, or 3750 ppm BA was applied to 10 hosta cultivars. BA application promoted offset formation in 8 cultivars at 30 days after treatment (DAT) and in all cultivars at 60 DAT. At 30 DAT, no offsets had formed in controls (0 ppm BA) of 'Halcyon' or 'Samuel Blue', but plants receiving 3750 ppm BA averaged 3.1 and 5.5 offsets, respectively. In the remaining cultivars at 30 DAT, maximum increases in offsets compared to controls ranged from 0.9 offset for 'Stiletto' to 6.2 offsets for 'Hyacinthina'. Untreated plnats of 'Halcyon' fomred no offsets by 60 DAT, whereas plants receiving 3750 ppm BA averaged 3.8 offsets. In the remaining cultivars at 50 DAT, maximum increases in offsets compared to controls ranged from 2.1 offsets for 'Great Expectations' to 7.6 offsets for 'Stiletto'. Offset stage of development, based on number of unfurled leaves, was more advanced in treated plants than in controls of two cultivars, less than that of cotnrols in two cultivars, and similar to control in the remaining cultivars. No phytotoxic symptoms were noted for any cultivar, and plant size was either increased or not affected by BA treatment

(45) Struve, D. K., M. A. Arnold, et al. (1994). The copper connection. Am nurserym 179(4): 52-54, 56-61.

(46) Arnold, M. A. and D. K. Struve (1993). Root distribution and mineral uptake of coarse-rooted trees grown in cupric hydroxide-treated containers. HortScience 28(10): 988-992.
Seedlings of nine coarse-rooted specie-sawtooth oak (Quercus acutissima Carruth), white oak (Q. alba L.), cherrybark oak (Q. falcata var. pagodifolia Elliott), post oak (Q. stellata Wangenh.), black walnut (Juglans nigra L.), pignut hickory [Carya glabra (Mill.) Sweet), pecan [C. illinoinensis (Wangenh.) C. Koch], Chinese chestnut (Castanea mollissima Blume), and common baldcypress [Taxodium distichum (L.) L. Rich]--were grown for one growing season in nontreated containers or in containers treated on their interior surfaces with white interior latex paint containing 100 g Cu(OH)2/liter. Seedlings of each species and container treatment were harvested twice: once after being transplanted from 3.2- to 15.0-liter containers and at the end of the growing season. Cupric hydroxide-treated containers decreased the amount of circled, kinked, and matted roots formed at the container wall-medium interface in all species tested. Plants grown in Cu(OH)2-treated containers also had altered root dry-weight partitioning. The partitioning patterns were species specific and included 6% to 20% increases in the percentage of root dry weight in interior vs. exterior portions of the rootball (white oak,

black walnut, Chinese chestnut, and baldcypress), 10% to 21% increases in the percentage of root dry weight in upper vs. lower halves of the rootball (sawtooth oak, cherrybark oak, black walnut, and baldcypress), and an increase in the percentage of primary lateral roots (lateral roots originating from taproots or.

(47) Barrett, J. E., C. A. Bartuska, et al. (1994). Comparison of paclobutrazol drench and spike applications for height control of potted floriculture crops. HortScience 29(3): 180-182.
Experiments with 'White Christmas' and 'Carolyn Wharton' caladiums (Caladium X hortulanum Birdsey), croton (Codiaeum variegatum) brassaia (Brassaia actinophylla Endl.), 'Annette Hegg Dark Red' poinsettia (Euphorbia pulcherrima Willd.), and 'Super Elfin Red' and 'Show Stopper' impatiens [Impatiens wallerana (L.) Hook. f.] determined effectiveness of paclobutrazol in solid spike form as compared to media drench applications for height control. Paclobutrazol drenches and spikes were effective for all crops tested, with a similar concentration response for all, except that drenches had greater efficacy than spikes on caladium. A reduced effect was observed when spikes were placed on the medium surface of 'Super Elfin Red' impatiens, while placement in the middle of the pot or around the side was equally effective. These results indicate that the spike formulation of paclobutrazol has potential to provide adequate size control for floriculture crops with the possible exception of rapidly developing crops, such as caladiums.

(48) McDaniel, G. L. (1986). Comparison of paclobutrazol, flurprimidol, and tetcyclacis for controlling poinsettia height. HortScience 21(5): 1161-1163.
Growth retarding activities of paclobutrazol, flurprimidol, and tetcyclacis were compared on 'Eckespoint C-1 Red', 'Annette Hegg Dark Red', and 'Gutbier V-14 Glory' poinsettia (Euphorbia pulcherrima Willd.). Paclobutrazol effectively controlled height of all cultivars at 0.50 mg per pot as soil drenches and at 25 - 50 mg/L as foliar applications. Flurprimidol soil drenches of 0.03 - 0.06 mg per pot and foliar sprays of 25 mg/L were equally effective in reducing plant heights of all cultivars. Tetcyclacis soil drenches and granular applications of 10 - 20 mg per pot provided similar reductions of plant heights on the cultivars tested.

(49) Arnold, M. A. and D. K. Struve (1989). Growing green ash and red oak in CuCO3-treated containers increases root regeneration and shoot growth following transplant. Journal for the American Society of Horticulture Science 114(3): 402-406.
Control of green ash (Fraxinus pennsylvanica Marsh.) and red oak (Quercus rubra L.) root growth in containers treated with CuCO3 and its effects on root regeneration following transplant were studied. Root elongation was controlled by applying 100 g CuCO3/liter of flat-white exterior acrylic latex paint to the interior surfaces of plastic containers. Plants grown in CuCO3-treated containers did not require root-pruning, whereas root-pruning was required to correct root deformations of plants grown in untreated containers. Root pruning removed up to 37% of root dry weight. When plants grown in CuCO3-treated containers were transplanted to 45.6-liter containers, root dry weight beyond the original root ball was greater than that ofroot-pruned seedlings transplanted from untreated containers. Seedlings transplanted from CuCO3-treated containers to field plots in July, August, or September showed enhanced shoot growth for two growing seasons compared with root-pruned control seedlings. Seedlings transplanted from CuCo3-treated containers appeared to suffer less stress than root-pruned control seedlings transplanted on the same date. Green ash seedlings transplanted in July had greater shoot growth than those transplanted in August and September over two growing seasons.

(50) Crisosto, C. H., P. B. Lombard, et al. (1987). Spring applications of ethephon and ethylene inhibitors on bloom delay, fruit set, and yield in 'Redhaven' peach. Acta Horticulturae(201): 195-201.
The effects of ethylene inhibitors and ethephon sprays on internal ethylene levels, spring bud break, fruit set, and yield were studied. Ethylene inhibitors applied at the bud swell stage reduced internal ethylene levels at bloom time. Aminoethoxyvinylglycine (AVG) was the most effective inhibitor that reduced internal ethylene levels in the peach buds. Internal ethylene bud levels during quiescence were 40% lower and 50% higher in winter applications of AVG and Ethephon respectively. This alteration of internal ethylene bud levels during quiescence had no effect on bloom delay, fruit set, and yield.

(51) Wilfret, G. J. and J. E. Barrett (1994). Effect of growth regulators on growth and flower development of potted azaleas. Proceedings of the annual meeting Florida State Horticulture Society, Orlando, Florida. 107: 175-177.
Plants of the florist azalea 'Prize' (Rhododendron obtusum Planch.) were grown in Gainesville and Bradenton, Florida during 1993. Plant growth regulators (PGRs) were applied as a foliar spray (paclobutrazol or daminozide) or media drench (paclobutrazol) 4 to 5 weeks after pinching. At Bradenton, all PGRs retarded plant height and plant diameter while at Gainesville only the paclobutrazol drenches or daminozide sprays affected plant growth. Number of days to flower was increased with the daminozide sprays at both locations and with the paclobutrazol were more effective in decreasing number of bypass shoots than media drenches or daminozide sprays. Paclobutrazol caused an increase in the number of multiple floral buds per lateral.

(52) Ruter, J. M. (1992). Growth and flowering response of butterfly-bush to paclobutrazol formulation and rate of application. HortScience 27(8): 929.

(53) Ruehle, J. L. (1985). The effect of cupric carbonate on root morphology of containerized mycorrhizal pine seedlings. Canadian Journal of Forestry Research 15(3): 586 - 592.
Loblolly (Pinus taeda L.), longleaf (Pinus palustris Mill.), shortleaf (Pinus echinata Mill.), and eastern white (Pinus strobus L.) pine seedlings inoculated with Pisolithus tinctorius (Pers.) Coker & Couch (Pt) were raised in a greenhouse in containers painted with latex paint containing 50 g/L cupric carbonate (CuCO3). To determine the effects of CuCO3 on root development and morphology, seedlings were sampled in the middle and at the end of the test. The treatment was effective in preventing most first-order laterals of all species from growing down the container wall, yet it had no significant effect on seedling height, root-collar diameter, or top and root fresh weight. Cupric carbonate had little effect on ectomycorrhizal formation on loblolly and shortleaf seedlings, but significantly increased it on longleaf seedlings and decreased it on eastern white seedlings. Using CuCO3 to alter root morphology of containerized southern pine seedlings inoculated with Pt has the potential for developing stock that will grow long laterals near the soil surface for anchorage and increase the rate of spread of Pt ectomycorrhizae from the plug to new roots after planting.

(54) Leonard, W. F. (1986). Cultar--a plant growth regulator for horticulture. New Zealand Agriculture Science 20(4): 195-202.

(55) Rowley, A. J. (1990). The effect of Cultar applied as a soil drench on Mauritius litchi trees. Acta Horticulturae(275): 217-221.
The warm subtropical climate of the South African Lowveld results in excessive vegetative growth and eventurally large, difficult to

manage trees. This management problem promoted the evaluation of Cultar for growth suppression efficacy. A trial was initiated in 1986 applying four treatments of Cultar to ten year old 'Mauritius' litchi trees. The treatments were re-applied in 1987 and 1988. Cultar reduced the length of vegetative shoot growth. Yield per tree was not affected in the first year but was substantially increased in the second year. Tree height was substantially reduced after 19 months. Name of chemical used: B-[(4-Chlorophenyl)methyl]-a-(1,1-dimethylethyl)-1H-1,2,4-triazol-1-ethanol (paclobutrazol).

(56) Shanks, J. B. (1980). Chemical dwarfing of several ornamental greenhouse crops with PP333. Proceeding of the Plant Growth Regulator Working Group Annual Meeting, Longmont, Colo.: 46-51.
PP333 reduced shoot extension in a wide range of ornamental species growing in the greenhouse applied to the soil in aqueous solution or as a 2% granular formulation using 1 mg or less per plant or 5 to 50 mg/m2. Whole plant sprays of 10 to 80 ppm pp333 were also effective in limited trials. Treated plants were dark green and free from any phytotoxicity symptom. Dwarfed plants included cultivars of Ageratum, Antirrhinum, Begonia, Celosia, Chrsanthemum, Cineraria, Coleus, Cosmos, Euphorbia, fuchsia, Gomphrena, Gardenia, Hibiscus, Hydrangea, Impatiens, Kalanchoe, Lycopersicon, Nephrolepis, Nicotiana, Pelargonium, Petunia, Plectranthus, Primula, Rhododendron, Tibouchina, vinca, and Zebiran. Lilium longiflorum was not affected.

(57) Struve, S. K. (1993). Effect of copper-treated containers on transplant survival and regrowth of four trees species. Journal of Environmental Horticulture 11(4): 196-199.
Northern red oak (Quercus rubra L.), scarlet oak (Q. coccinea Muenchh.), sweetgum (Liquidambar styraciflura L.), and 'Autumn Flame' red maple (Acer rubrum L.) liners were produced in copper-treated (100 gm Cu(OH)2/L white latex paint) or untreated black plastic 3.8 L conatiners (Lerio C-700) in 1989. In spring 1990, liners were transplanted into field plots. Half the liners produced in untreated containers were root pruned just before transplanting, half were not. Liners grown in copper-treated containers were not root pruned before transplanting. Survival percentage was high for all species ranging from 92% for red maple to 65% for scarlet oak. Three years after transplanting, red and scarlet oak liners produced in copper-treated containers had higher survival rates (but not statistically significant) and greater regrowth (taller, greater trunk caliper and percent central leader formation) than liners produced in untreated containers, whether root pruned or not before transplanting. Regrowth of red maple and sweetgum were not affected by container type used during liner production. The study demonstrates species differences to transplanting; each species responds to transplant via a unique combination of growth characteristics. Transplant responsees are expressed up to three years after transplanting.

(58) Struve, D. K. (1996). Bare root shade tree whip production in containers. Journal of Environmental Horticulture 14(1): 13-17.
A production system for producing bare root shade tree whips in containers is described. First year growth, transplant survival and regrowth of eight taxa were studied. Red oak (Quercus rubra L.) seedlings grown in 2:2:1, 2:1:2 or 3:1:1 sand:Comtil (composted municipal sewage sludge):Isolite (by vol) bare root media had first year height growth (100 cm, approximately 40 in) similar to seedlings grown in 3:0.5:0.5:1 pine bark:peat moss:Comtil:sand mdium (by vol). In a 2:2:1 sand:Comtil:Isolite (by vol) medium, red oak seedling height growth was greatest when 60 g (2.1 oz) slow release fertilizer was applied per container. Red oak seedlings were easily bare-rooted by hand shaking the sand:Comtil:Isolite media from the root systems. The root systems of all the taxa were fibrous and had many intact root tips. Red oak seedlings could be successfully transplanted in fall or spring. Six of the eight taxa studied, all except blackgum (Nyssa sylvatica Marsh.) and chinkapin oak (Q. Muehlenbergii Engelm.), could be successfully overwintered bare root in refrigerated storage. When spring transplanted to containers, survival averaged over 90%; second season height growth increased over 60 cm (24 in).

(59) Struve, D. K. and R. D. Lineberger (1985). Field transplant survival of Amelanchier liners produced by tissue culture. Research Circular of the Ohio Agriculture Research Development Center(2841): 1-3.
Tissue cultured Amelanchier laevis liners were transplanted to the field with almost complete survival. Plants trusplanted from Cone-Tainers were slightly shorter but had more lateral breaks 1 year after planting. A period of outdoor acclimation under 60% shade for as little as 5 days reduced trasplant shock as indicated by incremental growth at 1, 2, or 3 months, but were not affected by outdoor acclimation. Tissue cultured liners could be outplanted as late as early October and still overwinter without damage

(60) Holcomb, E. J. and D. J. Beattie (1990). Growth retardants for perennials. Proceedings of the Plant Growth Regulator Society of America, Saint Paul, Minnesota, Lake Alfred, Fla. : The Society.: 164-169.
Perennials could be grown as potted plants, but are normally too tall. The objective of this research awas to evaluate how several perennial species would respond to grwoth retardant application. Perennials were obtained as corms, tuberous roots, seedlings, rooted cuttings, bulbs, or crowns. When the plants were actively growing, growth retardants were applied either as a drench or a foliar spray. The effects of growth retardants varied with species, growth retardant, and method of application. For example, daminozide spray controlled the height of platycodon, uniconazole drench reduced the height of astilbe, coreopsis, delphinium, and liatris, while a uniconazole spray was effective on coreopsis and delphinium. Both uniconazole and paclobutrazole controlled the height of hybird lilies. The flowering height of perennials in containers can be restricted, except for liatris, if the correct growth retardant and rate is chosen.

(61) Webster, T. and J. Quinlan (1984). Research update with the growth regulator PP333 [Paclobutrazol, apple, sweet cherry, plums, Great Britain]. Compact Fruit Tree 17: 133-141.

(62) Rounkova, L. V. (1989). Effect of ethylene producing substances and cultar on some ornamental plants. Acta Horticulturae(251): 281-288.
Attempts were made to compare the influence of ethylene producing substances--ethrel, dextrel and kamposan with that of cultar in respect to chrysanthemum (Chrysanthemum coreanum, cultivar "Jantar"), phlox and dahlia. They were treated with ethrel, kamposan (1000 ppm), dextrel (5000 ppm) and cultar (25-50 ppm, trade name of paclobutrazol in USSR, ICI, England); as a surfactant tween-80 was applied. The plants were sprayed at the very beginning of vegetation when their height was 20-25 cm; the spraying was performed three times with a week interval. The treatment with ethylene producing substances resulted in a 40% growth decrease as compared to controls at the beginning of development. Then the inhibitory effect stopped, so at the vegetation end the stem length was the same as with untreated plants. Ethrel and kamposan inhibited flower initiation very strongly (30-40 days). So, it is impossible to use ethylene producting substances for obtaining pot-bedding cultures of examined plants. The cultar treatment reduced stem height (50% compared to control plants). It delayed flowering for 3-5 days; a shorter period of inflorescence was observed after this substances

application. Cultar continued its inhibitory action for 2 years after one year of treatment. Cultar is a very good substance for obtaining dwarfed form and therefore good for pot-bedding culture. As a result it is becoming possible to transplant the plants from field to greenhouse and vice versa.

(63) Curry, E. A. and A. N. Reed (1987). Partial reversion with GA3 of physiological changes induced by paclobutrazol and RSW0411 on plants with strong apical dominance. Proceedings of the Annual Meeting of Plant Growth Regulator Society of America, Honolulu, Hawaii: 160-165.
Paclobutrazol [(2RS,3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)pentan-3-ol] and RSW0411 [(E)-(RS)-1-cyclohexyl-4,4-dimethyl-2-(1h-1,2,4-triazol-1-yl)pent-1-en-3-ol] applied to the rooting medium control growth of sunflowers (Helianthus annuus L. cv. Russian Mammouth) grown in the greenhouse. Plant height was reduced 30-40% by both compounds. However, reduction in leaf area with RSW0411 was approximately half that of plants treated with paclobutrazol. Gibberellic acid (GA3) included with the treatments caused plant height to exceed that of controls however GA3 did not reverse the reduction in leaf area induced by the GA biosynthesis inhibitors.

(64) Mainland, C. M. (1989). Managing the growth and fruiting of rabbiteye (Vaccinium ashei Reade) blueberries with pruning and growth regulators. Acta Horticulturae(241): 195-200.
Winter pruning to control the height of excessively vigorous rabbiteye plants often results in declining yields. When bush height exceeds 1.8 m, had harvest is difficult and inefficient. Mechanical harvesting problems occur when bush heights exceed 2.4 m. Mature cv Delite bushes yielded an average of 4.6 kg for the 1984 through 1987 harvest seasons when summer pruning in late July was combined with winter pruning. With winter pruning alone, the yield was 3.0 kg/bush. Weigh[illegible]y was 0.12 greater with the combination of summer [illegible]er pruning than with winter pruning alone. Summer pru[illegible] consisted of cutting vigorous shoots more than 30 cm long tha[illegible] were initiated above a 90 cm height in the bush. Without summer pruning, the vigorous canes provided undesirable shade to shoots lower on the bush that were forming flower buds. Time required for the combination of summer plus winter pruning was 11.3 minutes compared with 10.4 minutes for winter pruning. Soil applications of the grwoth regulating chemical, beta[4-chlorphenyl)methyl)]-alpha-(1,1-dimethylethyl)-H-1,2,4-triazole-1-ethanol (paclobutrazol) reduced the vigor of mature 'Tifblue' plants, however, at the lowest effective rate of 2 g ai/plant, yields were also reduced.

(65) Adriansen, E. (1985). Height control of Beloperone guttata by paclobutrazol. Acta Horticulturae(167): 395-400.
In Denmark there is a preference for producing many pot crops to a height of 20-25 cm measured from the pot rim. With the available commercial growth-retardants it is impossible in warm summer periods to produce high-quality dwarfed pot plants of Beloperone guttata 'Norgaard'. Two experiments show that the new growth retardant paclobutrazol (PP333) can restrict extension growth in warm periods of July and August. One foliar spray with ethophon, 400 mg/L, followed by either 2 foliar sprays with paclobutrazol, 40 mg/L, or 3 foliar sprays with 20 mg/L restrict extension growth sufficiently at a time of year when the growth is vigorous. However, 80 mg paclobuarzol/L sprayed once after the ethephon foliar spray was slightly less than adequate. 160 mg/L results in crinkled leaves and indented edge in some leaves. It is suggested that an extra spray with paclobutrazol can substitute the ethephon foliar spray

(66) Kaminski, W. (1989). Alar and paclobutrazol use on roses. Acta Horticulturae(251): 407-410.
Paclobutrazol in a concentration of 150 ppm (from 'Bonzi') was much more effective than Alar in a concentration of 5000 ppm in the retardation of growth and the stimulation of flowering of young, 45 day old, 7 cm high seedlings of 'Paprika' cv. grown in pots. After the use of 'Bonzi, the plants had more compact growth, and their shoots were shorter and stiffer with darker green leaves. Though the flowers were somewhat smaller in diameter, the treated plants flowered more abundantly and were less sensitive to mildew than the non-treated plants and those on which Alar was used.

(67) Chinery, D. H., T. Rhodus, et al. (1991). Economic feasibility of a shade tree container production system. Journal of Environmental Horticulture 9(2): 105-108.
An ecomonic model was developed to estimate the feasibility of producing red oak (Quercus rubra) whips in an established container nursery. Cost per plant was compared for a simulated container nursery of 6.88 and 13.76 ha (17 and 34 acres) at different levels of production. Variable cost per plant ranged from $3.48 when producing 100 plants to $3.16 when producing 4,160 or more. Fixed cost per plant was $.42 to $.55 higher in the small nursery, depending upon level of production. Total cost per plant varied from $3.86 to $4.59, depending upon nursery size and level of production. Sensitivity analysis indicated that total cost per plant is less responsive to changes in wage rate than changes in interest rates on operating capital. Reducing losses during the rapid growth and overwintering phases of production is necessary in order to minimize total cost per plant.

(68) Gainer, B. L. (1998). Walking a Fine Line. American Nurseryman(March): 64-69.
Various commercially available plant growth regulators are discussed.

(69) Appleton, B. L. (1996). Try growth regulators to tame those 'wild things'. Nursery Management & Production(November): 56 - 57.

(70) Salisbury, F. B. and C. W. Ross (1992). Hormones and growth regulators: cytokinins, ethylene, abscisic acid, and other compounds (Chapter 18). Plant Physiology. Belmont, CA, Wadsworth Publishing Company: 382 - 407.

(71) Bandara, M. S., K. K. Tanino, et al. (1998). Effect of pot size and timing of plant growth regulator treatments on growth and tuber yield in greenhouse-grown Norland and Russet Burbank potatoes. Journal of Plant Growth Regulation 17: 75-79.
The effects of pot size, timing of the application of paclobutrazol (PTZ) and gibberellic acid (GA3) and counteractive effect of these two compounds on growth and tuber yield of greenhouse-grown Norland and Russet Burbank potatoes were investigated. Plants were grown either in 1.5-liter pots (15 cm deep) or 3.0-liter pots (18 cm deep) and received a foliar application of either 1.5 mM PTZ or 9 x 10-3 mM GA3 at early or late stolon initiation. Some plants that had been foliar treated with 1.6 mM PTZ at early stolon initiation were foliar treated with 9 x 10-3 mM GA3 at late stolon initiation. PTZ reduced haulm length in both cultivars significantly, particularly when the treatment was aplied at early stolon initiation, but the late treatment reduced haulm length only when growing in 3.0-liter pots. Irrespective of the timing of treatment, GA3 increased haulm length in Norland growing in both pot sizes, but the treatment increased haulm length in Russet Burbank only when applied at late stolon initiation. GA3 applied after PTZ did not overcome the growth-inhibiting effect of the PTZ treatment. The PTZ treatment effectively increased usable tuber number/plant (UTN) in Norland, but PTZ had no effect on UTN in Russet Burbank. PTZ reduced usable tuber weight/plant (UTW)

only in Norland growing in 1.5-liter pots. By contrast, GA3 increased UTN only when treated at late stolon initiation of 1.5-liter pot-grown Norland, whereas the same treatment was effective when applied only at early stolon initiation for Russet Burbank. For Norland, the increase in UTN by early applied PTZ was reduced by the subsequent application of GA3. The use of 3.0-liter pots for minituber production in both Norland and Russet Burbank appears to have no advantage over growing in 1.5-liter pots, particularly when PTZ or GA3 is used to enhance tuberization.

(72) Anon. Bonzi Plant G owth Regulator Label (CANADIAN). P. P. C. L. a. u. o. t. trademark) and Z. L. B. r. t. owner). 314 Orenda Road
Bramptom, ON L6T 1G1.

(73) Salisbury, F. B. and C. W. Ross (1992). Hormones and growth regulators: auxins and giberellins (Chapter 17). Plant Physiology. Belmont, CA, Wadsworth Publishing Company: 357-381.

(74) Anon. Confer Plant Growth Regulator for Conifer Seedlings Label (CANADIAN). Z. Agro. Stoney Creek, ON L8G 3Z1.

(75) Anon. Bonzi Plant Growth Regulator. U. Chemical: 1-7.

(76) Anon. Promalin Plant Growth Regulator Solution Label (US). A. Laboratories. D-90F, A1-3
1401 Sheridan Rd
North Chicago, IL 60064.

(77) Anon. Promalin Plant Growth Regulator Solution Label (CANADIAN). A. Laboratories. Chemical and Agricultural Products Division
PO Box 6150
Montreal, QU H1T 1Z1.

(78) Balamani, V. and B. W. Poovaiah (1985). Retardation of shoot growth and promotion of tuber growth of potato plants by paclobutrazol. American Potato Journal 62: 363 - 369.
The relationship between shoot growth and tuber yield in potato plants (Solanum tuberosum L. cv. Russet Burbank) was studied under greenhouse conditions using paclobutrazol [(2R,3R + 2S,3S)-1-(4-cholorphenyl)-4,4-dimethyl-2-(1,2-4-triazol-1-yl)-pentan-3-ol), PP333], a growth retardant. Concurrent with reduction of stem elongation by the application of paclobutrazol to base of the main stem was a decrease in the dry weight of the shoot and an increase in the dry weight of the tuber. The inhibitory effect of paclobutrazol on stem elongation was reversed by gibberellic acid A3 (GA3). Leaf content of raffinose sugar and chlorphyll increased upon paclobutrazol treatment.

(79) Retzlaff, W. A. and D. B. South (1985). A simple method for determining a partial soil water retention curve. Tree Planters Notes 36(4): 20-23.
Nursery managers can develop their own partial soil water retention curves. Developing these cureves can provide nursery managers with a better understanding of the soil moisture relationships for the various soils at their nurseries.

(80) Chapman, H. D. and P. F. Pratt (1961). Methods of analysis for soils plants and waters. Davis, CA, University of California.

(81) Brewster, G. and D. Higgins (1991). CS220: Introduction to Soil Science, Nova Scotia Agricultural College.

(82) Gill, S., R. Balge, et al. (1997). A new closed loop system. Am. Nurseryman(October): 68-70, 72, 74, 76, 78-79.
Research in the Cellugro inground production system shows that it could be a useful method for growing woody plants and perennials while conserving and recycling water

(83) Anon. Cellugro plant production system. A. Environmental. Richmond, VA, ACF Environmental.

(84) Alder, G. M. and W. K. Ostler (1989). Native shrub propagation and nursery stock production. The biology and utilization of shrubs, Academic Press: 535 - 552.

(85) Swanson, B. T. and J. B. Calkins (1994). Effect of container size on plant growth: 1993 - 1995. 1994 Nursery and landscape projects and programs. B. T. Swanson, J. B. Calkins and J. A. Lutz. St. Paul, University of Minnesota: 87 - 94.

(86) Calkins, J. B. and B. T. Swanson (1994). Effects of Tubex tree shelters on plant performance. 1994 Nursery and Landscape projects and programs. B. T. Swanson, J. B. Calkins and J. A. Lutz. St. Paul, University of Minnesota: 119 - 129.

(87) Dickinson, S. and C. E. Whitcomb (1982). Root development of transplanted seedlings initially in bottomless milk cartons. Journal of Arboriculture 8(12): 323 - 324.
Pecan, Carya illinoensis 'Western', and sawtooth oak, Quercus acutissima, seedlings were grown in containers 5.5 x 2.75 x 2.75" without bottoms and on a wire bench for 10 weeks prior to being planted into the field. The tree seedlings were dug after 30 days and evaluated for root growth. Both species had produced numerous new roots in excess of 8 inches in length. However, the pecan roots were course and had few branches, whereas, the sawtooth oak had a very fibrous root system.

(88) Latimer, J. G., R. D. Oetting, et al. (1996). Reducing the pollution potential of pesticides and fertilizers in the environmental horticulture industry: I. Greenhouse, nursery and sod production. HortTechnology 6(2): 115 - 124.
Pesticides have been the primary method of pest control for years, and growers depend on them to control insect and disease-causing pests effectively and economically. However, opportunities for reducing the potential pollution arising from the use of pesticides and fertilizers in environmental horticulture are excellent. Greenhouse, nursery, and sod producers are using many of the scouting and cultural practices recommended for reducing the outbreak potential and severity of disease and insect problems. Growers are receptive to alternatives to conventional pesticides, and many already use biorational insecticides. Future research should focus on increasing the effectiveness and availability of these alternatives. Optimizing growing conditions, and thereby plant health, reduces the susceptibility of plants to many disease and insect pest problems. Impediments to reducing the use of conventional pesticides and fertilizers in the environmental horticulture industry include 1) lack of easily implemented, reliable, and cost-effective alternative pest control methods; 2) inadequate funding for research to develop alternatives; 3) lack of sufficient educational or resource information for users on the availability of alternatives; 4) insufficient funding for educating users on implementing alternatives; 5) lack of economic or regulatory incentive for growers to implement alternatives; and 6) limited consumer acceptance of aesthetic damage to plants. Research and broadly defined educational efforts will help alleviate these impediments to reducing potential pollution by the environmental horticulture industry.

(89) Williamsn, H. G. and B. E. Maust (1996). Forcing treatment and rootstock affect budbreak and growth of containerized citrus nursery trees. HortTechnology 6(2): 134-137.

Two experiments were conducted to determine the effects of rootstock and bud-forcing treatment on scion budbreak and nursery tree growth of 'Hamlin' orange. In Expt. 1, 'Carrizo' citrange, 'Swingle' citrumelo, and 'Cleopatra' mandarin were budded with 'Hamlin' orange and forced by one of the following methods: cutting off (pruning away the rootstock top about 2 cm above the inserted scion bud); lopping (cutting half to two-thirds of the way through the rootstock stem 2 cm above the bud union, and breaking over the stem but leaving it attached); or bending (bending the rootstock shoot above the inserted scion bud and tying it to the base of the plant). For 'Swingle only, percent budbreak was less for bending or looping compared to cutting off. For 'Carrizo' and 'Swingle', scion dry weights were less when plants were forced by cuting off compared to bending or lopping. For all rootstocks, whole-plant dry weights were greater for plants forced by bending and lopping than for plants forced by cutting off. In Expt. 2, scion buds on 'Swingle' and 'Cleopatra' plants were forced by the three methods in Expt. 1 plus combinations of bending with notching (making an inverted V incision through the bark and into the wood on the rootstock stem directly above the scion bud) and/or topping (removing the terminal 2 cm of the rootstock shoot tips of plants forced by bending). Percent scion budbreak was high for 'Cleopatra' plants regardless of forcing treatment. For 'Swingle', scion budbreak was greater when bending was combined with notching than for bending alone. For 'Cleopatra', plant dry weight was greatest for plants forced by lopping. When bending was combined with notching, or notching with topping, 'Swingle' scion budbreak was comparable to cutting off, but plant dry weights were greater with these combination treatments than when cutting off was used.

(90) Whitcomb, C. E. (1986). Fabric field-grow containers enhance root growth. Am. Nurseryman(April): 49-52.

(91) Gibson, J. D. (1986). Square, bottomless containers spare plant roots. Am. Nurseryman 163(2): 37-41.

(92) Lumis, G., P. Purvis, et al. (1996). Growth of hybrid poplar in in-ground fabric containers and their response to transplanting. Landscape Trades(June): 26 - 27, 30 - 31, 44, 47.

(93) Colombo, S. J. and E. M. Raitanen (1993). Frost hardening in first-year eastern larch (Larix laricina) container seedlings. New Forests 7: 55-61.
Eastern larch (Larix laricina [du Roi] K. Koch) container seedlings were tested to determine shoot frost hardiness development under short or long days and warm (15 to 25 C) or cool (10/5 C, day/night) temperatures, to aid in the development of greenhouse hardening strategies. Seedlings were sampled sequentially over time (25 seedlings per week) from a population of 1000 trees. Frost hardiness increased significantly after one week of intermittent (4 consecutive days per week) short day treatment at warm temperatures, fluctuated over the next 6 weeks, and increased thereafter through week 14. Seven weeks of warm, intermittent short days, followed by 6 weeks of cool, continuous short days, resulted in greater frost hardiness than 13 weeks of warm, intermittent short days. In contrast, seedlings exposed to 7 weeks of warm, intermittent short days followed by six weeks of warm, long days were significantly less frost hardy. Stems with needles attached had lower Index of Injury than stems without needles.

Application: Strategies for frost hardening eastern larch container seedlings in greenhouses in preparation for over-wintering outside can be predicated on the rates of frost hardening found in this trial under intermittent (four consecutive days per week) short day treatment and warm temperatures. Seedlings were minimally damaged by -10 C ten weeks after the start of the short days. Exposure to long days after 7 weeks of intermittent short days caused a loss of frost hardiness even without a resumption of growth.

(94) Hedger, J. M. (1984). Container tree production. Comb Proc Int Plant Propagators Soc, Boulder, Colorado. 34: 287-290.

(95) Beeson, R. C., Jr. (1993). Benefits of progressively increasing container size during nursery production depend on fertilizer regime and species. Journal for the American Society of Horticulture Science 118(6): 752-756.
Rooted photinia (Photinia X fraseri) cuttings and bare-root slash pine (Pinus elliottii Engelm.) seedlings were transplanted initially into 0.9-, 2.9-, and 10.2-liter containers. A subset of these plants was transplanted from 0.9- and 2.9-liter containers into the next larger container size in the series (upcanning) until representative plants of each initial container size were growing in 10.2-liter containers. The photinia experiment was conducted with two fertilizer regimes [soluble vs. controlled-release (CR) fertilizer] superimposed. When CR fertilizer was used, upcanning from 2.9- to 10.2-liter containers produced the largest photinia. However, for pine, there was no advantage due to upcanning. When soluble fertilizer was used, photinia initially transplanted into 0.9-liter containers and upcanned to 2.9- and then to 10.2-liter containers had superior growth compared to those of other fertilizer X container combinations. Upcanning generally maintained or increased plant growth rate, while growth rates of plants kept in the same container generally declined the second season. Improved efficiency of the root system in nutrient absorption of upcanned plants is proposed as the mechanism for this response.

(96) Martin, C. A. and D. L. Ingram (1993). Container dimension affects rooting medium temperature patters. HortScience 28(1): 18-19.
Computer modeling was used to study the effect of container volume and shape on summer temperature patterns for black polyethylene nursery containers filled with a 4 pine bark:1 sand (v/v) rooting medium and located in Phoenix, Ariz. (lat. 33.5 degrees N, long. 112 degrees W) or Lexington, Ky. (lat. 38.0 degrees N, long. 84.4 degrees W). For both locations, medium temperatures were highest at the east and west container walls, halfway down the container profile, regardless of container height (20 to 50 cm) or volume (10 to 70 liters). The daily maximum medium temperature (T(max)) at the center was lower and occurred later in the day as container volume was increased because of an increased distance to the container wall. For both locations, predicted temperature patterns in rooting medium adjacent to the container wall decreased as the wall tilt angle (TA) increased. Predicted temperature patterns at the center of the container profile were lowered in response to the interaction of increased container height and wall TA. As container height decreased, the container wall TA necessary to lower center T(max) less than or equal to 40 degrees C increased; however, the required increase in TA was greater for Phoenix than for Lexington, principally because of higher ambient air temperatures.

(97) Svihra, P., D. W. Burger, et al. (1993). Treeshelters for nursery plants may increase growth, be cost effective. Calif Agric 47(4): 13-16.
We tested the efficacy of treeshelters on selected container-grown trees in the nursery and on redwood seedlings transplanted into the landscape. Treeshelters accelerated shoot growth of southern magnolia, holly oak and deodar cedar, but root growth was reduced during the first growing season as compared to the controls. Suficient shoot-root development of the trees was achieved only after two growing seasons. One-year-old redwood

seedlings successfully established themselves whether grown in treeshelters or not, while receiving 1/7 to 1/14 as much water as they would in a nursery bed grown in one-gallon containers. The seedlings in treeshelters grew significantly taller.

(98) Khatamian, H. and M. L. Agnew (1984). Inserts on container walls reduce root spiraling [Potted plants, silver maple and oleaster tree seedlings]. Am Nurseryman 159(4): 61-63.

(99) Pierlot, R. (1974). Multibag, new type container for tree seedlings. Tree Plant Notes 25(2): 1.

(100) Scarratt, J. B. (1972). Container size affects dimensions of white spruce, jack pine planting stock. [Picea glauca, Pinus banksiana]. Tree Planters' Notes 23(4): 21-25.

(101) Ward, T. M., J. R. Donnelly, et al. (1981). The effects of containers and media on sugar maple seedlings growth Acer saccharum. Tree Plant Notes U S Forestry Service 32(3): 15-17.
Sugar maple seedlings grown for 20 weeks in 9.0-liter plastic containers filled with a peat-perlite-sand medium were larger than those grown in any of eight other container-medium combinations

(102) Appleton, B. L. and C. E. Whitcomb (1983). Effects of container size and transplanting date on the growth of tree seedlings. Journal of Environmental Horticulture 1(4): 89-93.
Superior growth was obtained from deciduous and coniferous trees seeded into the largest volume propagation container. This effect remained evident through the second growing season for all species. In a second experiment, larger containers were in some cases better, but attempts to improve growth by means other than an increase in propagation volume proved futile. Earlier transplant dates were much less important than container size.

(103) Lumis, G. P. and S. A. Struger (1988). Root tissue development around wire-basket transplant containers. HortScience 23(2): 401.

(104) Tilt, K., C. Gilliam, et al. (1992). Growth of container-grown trees transplanted from the field or grow-bags. HortTechnology 2(3): 415-417.
Crape myrtle (Lagerstroemia L. x 'Natchez'), live oak (Quercus virginiana Mill.), and Chinese pistachio (Pistacia chinensis bunge) were planted into a sandy loam soil directly in the field or in grow-bags. Root and top growth were measured in March and July of the second year. Some of the trees were transplanted to 20-gal (76-liter) containers in March or July and grown for 3 months. Chinese pistachio developed a poor root system in field soil and was not ready for harvest in March or July. There was no difference in height, caliper, or top fresh weight for crape myrtle. Caliper and top fresh weight were similar for live oak trees. However, live oaks grown by traditional field production methods were taller than trees produced in grow-bags. With March transplanting, both crape myrtle and live oak trees from traditional field plantings were taller than trees transplanted from grow-bags 3 months after transplanting into containers. Tree top weight, caliper, and root ratings ere similar for March-transplanted crape myrtle. Live oak trees transplanted from grow-bags had similar caliper and top weight but a higher root rating. July-transplanted crape myrtle trees had similar values for all variables 3 months later. All live oaks died when transplanted from traditional field plantings to containers in July. All live oaks grown in grow-bags survived transplanting.

(105) Milbocker, D. C. (1991). Low-profile containers for nursery-grown trees. HortScience 26(3): 261-263.
Pyrus calleryana, Decne. 'Aristocrat'; Cryptomeria japonica, D. Don; Populus maximowiczii, Henry X 'Androscoggin' and Koelreuteria bipinnata, Franch. trees were grown in low-profile containers. The optimum height and width of these containers was 20 to 30 cm and 84 cm, respectively. Pine bark and mixtures containing 50% or more of pine bark were preferable to mixtures containing leaf mold for filling the containers because the former weigh less. Roots penetrated pine bark mixtures better than sphagnum peat mixtures and also retained their shape better during transplanting. When grown in low-profile containers, trees grew fibrous root systems; after transplanting, roots grew downwardly radial and trees were able to withstand extremely difficult landscape conditions.

(106) Reiger, K. (1988). The bag way: root-control bags are a feasible alternative to the B&B method of growing and transplanting trees and shrubs. Am Nurseryman 168(10): 117-119.
Root-control bags are a feasible alternative to the B&B method of growing and transplanting trees and shrubs

(107) Rieger, M. and F. Marra (1994). Responses of young peach trees to root confinement. Journal for the American Society of Horticulture Science 119(2): 223-228.
Rooted cuttings of Nemaguard peach [Prunus persica (L.) Batsch.] were grown in 0.18-, 0.36-, 0.90-, and 2.40-liter containers for 16 weeks to study the influence of root confinement on growth, gas exchange, water uptake, and leaf carbohydrate and nutrient content. An automatic nutrient-solution dispensing system was used to ensure uniform fertility among treatments and to prevent drought stress. Leaf area and stem length were reduced by root confinement 6 to 7 weeks after transplanting, and differences among treatments increased throughout the experiment. Final tree dry weights were reduced by 51% over a 13-fold reduction in rooting volume, but dry weight partitioning was largely unaffected. A temporary limitation to CO2 assimilation (A) and leaf conductance (g) was observed just after budbreak, but consistent reductions in A and g for confined trees did not occur until after week 11. Sorbitol and starch accumulated earlier in leaves of trees in smaller containers than larger containers. Despite similar fertility, concentrations of all nutrients except N and Cu were reduced approximately 2-fold for trees in 0.18-liter containers compared to other treatments. However, characteristics of nutrient deficiency were not observed on any trees, and growth reduction with no change in leaf nutrient content was observed in other treatments. It was concluded that the initial mechanisms limiting growth were not gas exchange rates, levels of nonstructural carbohydrates, or drought stress, although nutrient deficiency may have contributed to growth limitation in trees with severely confined root systems.

(108) Beeson, R. C., Jr. (1994). Water relations of field-grown Quercus virginiana Mill. from preharvest through containerization and 1 year into a landscape. Journal for the American Society of Horticulture Science 119(2): 169-174.
Large (approximately 5 m high) Quercus virginiana Mill. (live oak) trees produced in 0.64-m-diameter in-ground fabric containers were root pruned or not root pruned inside containers before harvest. Harvested trees were grown in two sizes of polyethylene containers for 10 months, then transplanted into a landscape. Water potential of small branches (< 4 mm in diameter) was measured diurnally during containerization and for 1 year in the landscape. Root pruning had no influence on postharvest survival. Neither root pruning nor container size affected tree water status during containerization or in the landscape. All surviving trees recovered from transplant shock following harvest after 16 weeks in a container, independent of treatment. In the landscape, 35 weeks of daily irrigation were required before dusk water potential declined to within 0.1 MPa of

predawn values, a result indicating alleviation of transplant shock. Trunk growth rate during containerization was highest in larger containers. However, in the landscape, root pruning and small containers were associated with higher trunk growth rate. Tree water status during containerization and in the landscape is discussed.

(109) Burger, D. W., P. Svihra, et al. (1992). Treeshelter use in producing container-grown trees. HortScience 27(1): 30-32.
Treeshelters were used for the nursery production of Cedrus deodara Loud. (deodar cedar), Quercus ilex L. (holly oak), and Magnolia grandiflora L. (southern magnolia) trees growing in 19-liter containers. Air temperature, relative humidity, and CO2 concentration were higher inside the treeshelters than outside. Trees grown inside treeshelters were 74% to 174% taller than trees grown without shelters. Trunk caliper of Magnolia and Quercus was not affected; however, for Cedrus trees caliper was larger for trees grown without a shelter. Upon removal of the shelter, Cedrus trees were incapable of supporting their own weight. Lateral branch development was inhibited and leaf senescence was greater with Magnolia trees grown in a shelter. Quercus trees grown in shelters were ready to be transplanted into the landscape. Water use was similar for trees grown with or without shelters. Trees grown in shelters had lower root fresh weights.

(110) Whitcomb, C. E. (1985). Root development of trees grown in Field-Grow fabric containers following transplanting. Res Rep P Agric Exp Stn Okla State Univ(872): 38-40.

(111) Davis, R. E. and C. E. Whitcomb (1975). Effects of propagation container size on top and root development of tree seedlings [Cultivation of horticultural plants]. Res-Rep-P-OSU-Agric-Exp-Stn-Okla-State-Univ, 724: 21-24.

(112) Smith, W. H. (1977). Rootrainers [Container growing, tree propagation]. Wood-South-Afr 2(6): 7, 9, 33.

(113) Gibson, J. D. and D. M. Granberry (1984). Influence of container size and soil amendments on field transplanted container grown tree seedlings. Proceedings of the Southern Nurserymen's Association Conference/Annual Report of the Southern Nurserymen's Association
(Proc S N A Res Conf Annu Rep South Nurserymen's Assoc), Nashville, Tennisee: 29-33.

(114) Wagar, J. A. (1986). Pot test of fabrics for constraining tree roots. J-Arboric 12(4): 96.

(115) Harris, R. W., A. T. Leiser, et al. (1973). Nursery spacing container-grown trees. Calif-Agr 27(3): 12-14.

(116) Kenyon, B. S. (1987). Integrating field and container production of trees. Combined Proceedings of the International Plant Propagators Society
(Comb Proc Int Plant Propagators Soc), Hershey, Pennsylvania. 36: 582-585.

(117) Myers, S. C. Root restriction of apple and peach with in-ground fabric containers. Acta Horticulturae(322): 215-219.
Unfeathered trees of 'Golden Delicious'/MMIII apple and 'Winblo'/Lovell peach were planted conventionally (control) in in-ground containers of 0.02, 0.043 or 0.1 m3 volume. Apple trees were trained to a central leader with minimal pruning. Peach trees were unpruned and developed natural crown. Peach and apple trees in all treaments were developed as nonsupported, free-standing trees. All trees were allowed to crop naturally and remained unthinned.

Root restriction reduced canopy volume in apple and peach; and within container treatments, growth control increased linearly with decreasing container volume. During the third growing season, there was no treatment difference in fruit number per tree, total fruit weight per tree, or mean fruit size in peach. An average 44% reduction in tree size resulted in an increase in yield efficiency in root-restricted peach trees. Fruit-maturity period was concentreated and advanced in peach trees grown in fabric containers.

In the third season of growth, apple trees grown in fabric containers had a higher flower cluster number and percent fruit set than control trees. Within container treatments, flower cluster and fruit number per limb increased linearly with decreasing container volume.

(118) Anon. Pot-In-Pot growing system with exclusive SpinOut root growth regulator. T. L. Corporation. Mobile, AL.

(119) Anon. (1994). The key to growing quality liners. G. Corporation. Valdosta, GA: 1-2.

(120) Anon. (1996). Getting the most out of SpinOut. Griffin: 1-2.

(121) Anon. 16 Steps to remember when using root control bags. I. Root Control. Oklahoma City, OK: 1-2.

(122) Anon. Root control (Inc.) bag growing system. I. Root Control. Oklahoma City, OK: 1-4.

(123) Sallee, K. (1991). Growing landscape trees with pride. Nursery Manager.

(124) Whitcomb, C. E. The Whitcomb system for growing trees. L. Inc. Stillwater, OK.

(125) Smith, E. M. (1979). Fertilization practices for field-grown nursery stock. Am Nurserym 149(9): 9, 62-65.

(126) Hinesley, L. E. and T. E. Maki (1980). Fall fertilization helps longleaf pine nursery stock. South J Appl For 4(3): 132-135.
Fall fertilization resulted in substantial overwinter dry weight gains and increases in nutrient content and concentrations in one-year-old longleaf pine (Pinus palustris Mill.) nursery stock. Recovery of applied nutrients in the seedling crop was greatest for N. In the field, height growth and the rate of emergence from the grass stage were improved as a result of fall fertilization in the nursery. The practice thus offers a means of increasing seedling size and nutrient reserves prior to outplanting on the relatively infertile sites where seedlings are normally established.

(127) Davee, D. E., T. L. Righetti, et al. (1986). An evaluation of the DRIS approach for identifying mineral limitations on yield in 'Napolean' sweet cherry. Journal for the American Society of Horticulture Science 111(6): 988-993.
The ratio-based Diagnosis and Recommendation Integrated System (DRIS) was used to evaluate the mineral status of 'Royal Ann' sweet cherry trees. Standard ratios were developed from experimental research plots and then applied to evaluate the nutritional status of a large number of trees in a commercial orchard. DRIS indices for each element were calculated from a formula, which included DRIS standard ratios, their standard deviations, and the observed ratios from the sample being calculated. Nutritional Imbalance (NII) were compared as the sum

of Dris indices irrespective of sign. By selecting a sufficiency range that produced the best agreement with DRIS evaluations, independent sufficiency ranges were derived from the commercial orchard data. Trees with high NIIs were consistently low-yielding, and, in mulching treatments where unfavorable NIIs were improved, yields were increased. The NII was more strongly correlated with relative yield increases than any other mineral parameter. The data imply that it is possible to develop useful DRIS standards and DRIS derived sufficiency ranges from survey data, even though conventional statistical approaches do not reveal strong relationships between mineral concentration and yield.The ratio-based Diagnosis and Recommendation Integrated System (DRIS) was used to evaluate the mineral status of 'Royal Ann' sweet cherry trees. Standard ratios were developed from experimental research plots and then applied to evaluate the nutritional status of a large number of trees in a commercial orchard. Dris indices for each element were calculated from a formula, which included DRIS standard ratios, their standard deviations, and the obserbed ratios from the sample being calculated. Nutritional Imbalance (NII) were compared as the sum of Dris indeces irrespective of sign. By selecting a sufficiency range that produced the best agreement with DRIS evaluations, independent sufficiency ranges were derived from the commercial orchard data. Trees with high NIIs were consistently low-yielding, and, in mulching treatments where unfavorable NIIs were improved, yields were increased. The NII was more strongly correlated with relative yield increases than any other mineral parameter. The data imply that it is possible to develop useful DRIS standards and DRIS derived sufficiency ranges from survey data, even though conventional statistical approaches do not reveal strong relationships between mineral concentration and yield.

(128) Weinbaum, S. A., M. L. Merwin, et al. (1978). Seasonal variation in nitrate uptake efficiency and distribution of absorbed nitrogen in non-bearing prune trees. J. Amer. Soc. Hort. Sci.
Non-bearing prune (Prunus domestica L. cv. Agen) were fertilized with 15N-KNO3 for 10 days during 9 phenological periods. Nitrate uptake efficienty (NUE) and the distribution of absorbed 15N in the trees were determined for each of these application periods. Nitrate uptake was dependent on presence of leaves, and NUE was low from the period of natural leaf fall until shoot growth had commenced the following spring. NUE increased dramatically during the rapid phase of shoot elongation, and remained high until leaf fall. Nitrogen absorbed from fertilizer was rapidly mobilized by swelling buds and rapidly elongating shoots. The spring flush of vegetative growth utilized both the currently available fertilizer (15N) nitrogen and tree nitrogen reserves. Rapid shoot elongation was primarily dependent, however, on the redistribution of storage N.

(129) Whalley, D. N. (1974). Nutrition of hardy ornamental nursery stock. [Fertilizers, cultivation]. ADAS Q. Rev. 13: 27-41.

(130) Donald, D. G. M. and D. G. Simpson (1985). Shallow conditioning and late fertilizer application effects on the quality of conifer nursery stock in British Columbia. Research Note, British Columbia, Ministry of Forests(99): i-viii, 1-36.
Shallow undercutting and wrenching (conditioning) of British Columbia conifers was compared with the standard nursery regime. The applications of a complete NPK fertilizer some 50 days prior to lifting was also tested. Shallow conditioning combined with late fertilizer application can improve the root growth capacity at lifting of the conifers grown in British Columbia. It cannot replace cold exposure as a method of hardening Douglas-fir, and although it had no adverse effect on the other species tested, it had minimal effect on survival after field planting and reduced initial height increment.
The application of fertilizer just prior to lifting can improve the early growth of the trees without adversely affecting survival, and warrants additional work to quantify type and rate of fertilizer for each species. Planting seedlings some 5 cm deeper than they stood in the nursery proved an effective way of improving their establishment.

(131) Korneva, N. I. and A. R. Tsyganov (1990). Determination of optimal fertilizer dose for fruit trees and methods of nitrate diagnosis. Acta Horticulturae(274): 249-256.
A twenty-year experiment showed a positive response of orchards, berry-fruit plantations and nursery gardens to fertilization of turf podzolic light loams with an average percentage of nutrient elements in the process of planting and exploitation. The choice of optimum rates of mineral and organic fertilizers was determined by the variety, time and method of applying fertilizers. This work gives the results of the comparative study of 4 methods for determining the content of nitrates in the soil and plant tissues.

(132) Edwards, I. K. (1982). Maintaining soil fertility in forest nurseries in the prairie provinces. Inf Rep NOR X North For Res Cent(241): 47-54.
The six largest forest nurseries in the prairie provinces occupy a total of 358 ha and together produce 34 million bare-root seedlings annually. Soil properties vary. Most have a suitable texture and organic matter content, but most also have unsuitably high pH and salinity. Soil fertility is maintained through the application of amendments such as green manure, sphagnum peat, sand, sulfur, and sulfuric acid as well as fertilizers. It is suggested that more intensive monitoring of the seedling production system be pursued in future in order to compensate as much as possible for variation is stock quality due to weather.

(133) Tillet, N. D., S. J. Miles, et al. (1992). Techniques for adding minor ingredients to containerized nursery stock compost. J Agric Eng Res 52(4): 241-248.
An alternative to adding minor ingredients such as lime and controlled-release fertilizers to compost during bulk mixing has been investigated. This involves metering the minor ingredients into the compost stream as it fills containers. The technique allows fewer compost mixes to be stored, increases compost shelf life and makes it easier to tailor ingredients to individual plant varieties, especially for short runs. Experimental trials have been conducted to investigate how variability in the distribution of minor ingredients changes between the two mixing techniques. The results show that metering granular controlled-release fertilizer into compost as it is used reduces the coefficient of variation between containers from 0.21 to 0.07. The results of a similar trial with powdered lime (calcium carbonate) show that the variability in acidity was not significantly affected by the choice of technique.

(135) Parish, R. L., P. P. Chaney, et al. (1988). A dibble fertilizer applicator for containers in nursery beds. Journal of Environmental Horticulture 6(2): 63-66.
A machine to punch dibble holes in multiple filled containers and simultaneously to meter fertilizer has been designed, built and tested. The machine handles up to 12 containers at a time in beds 6 containers wide. Transported and powered by a tractor, this machine straddles the containers in a nursery bed. Alignment of the mechanism over the containers and the dibble operation itself are accomplished hydraulically. Force and speed of the dibbles are adjustable. Uniformity of metering is good, with coefficients of variation in the range of 2 to 3 %.

(136) Smith, E. M. and S. A. Treaster (1991). Nitrogen, phosphorus and potassium container plant rate study. Spec Circ

Ohio Agric Res Dev Cent(137): 25-27.
Optimum growth as a function of slow-release fertilizer treatments over a two-year period of container-grown Hino Pink azalea, Emerald Gaiety enouymus and Blue Rug juniper occurred at 2.0 lbs. actual nitrogen/cu yd., 1.0 lb. P205 and 1.0-2.0 K20 depending on species. High rates of nitrogen were phytotoxic and high rates of P205 and K20 were non-phytotoxic but were not needed.

(137) Hicklenton, P. R. and K. G. Cairns (1992). Solubility and application rate of controlled-release fertilizer affect growth and nutrient uptake in containerized woody landscape plants. Journal for the American Society of Horticulture Science 117(4): 578-583.
Nutrient release from Nutricote Type 100 (100-day N release; 16N4.4P-8.1K), and from a 1:3 mixture of Nutricote Type 40 (40-day N release; 16N-4.4P-8.1K) and Type 100 was affected by time and temperature. The Type 40/100 mixture released nutrients more rapidly over a 5 to 35C range in laboratory studies. Seasonal growth of containerized cotoneaster (Cotoneaster dammeri C.K. Schneid 'Coral Beauty') and juniper (Juniperus horizontalis Moench. 'Plumosa Compacta') increased with increasing application rates of either Nutricote Type 100 or a 1:3 mixture of Type 40/100 over the range 2-10 kg.m-3. Between 25 June and 27 July, cotoneaster grew more rapidly in media with Type 40/100 Nutricote, but by the end of the season (27 Sept.), fertilizer type showed no effect on plant dry weight. Shoot N was higher in cotoneaster plants grown with Type 40/100 Nutricote than with the Type 100 formulation during the first 2 months of growth, reflecting the more rapid release and uptake of N from the mixture. During the last month the situation was reversed, as nutrients from the Type 40/100 mixture were depleted. Potassium and P shoot concentrations were not affected by fertilizer type. Juniper growth and shoot concentrations of N, K, and P were not affected by fertilizer type at any time during the season. The results provided no evidence that seasonal growth could be enhanced in either cotoneaster (grows rapidly) or juniper (slower growing) by mixing rapid and more slowly releasing types of Nutricote.

(138) Smith, E. M. and S. A. Treaster (1991). A comparison of slow-release fertilizers for the nursery industry. Spec Circ Ohio Agric Res Dev Cent(137): 16-18.
Ten slow-release fertilizers at three rates were evaluated on container-grown azalea, cotoneaster and euonymus. Plant growth was acceptable with all treatments. The most consistent growth was observed in plants fertilized with nutricote followed by plants in Osmocote treatments. Plant growth in treatments as 2.0 and 2.5 lbs. N.cu. yd. was as good as plants in the 3.0 lb treatments.

(139) Cobb, G. S. and G. A. Holt (1984). Fertilizer application techniques for container-grown woody ornamentals. Proc S N A Res Conf Annu Rep South Nurserymen's Assoc(29th): 35-39.

(140) Still, S. M., C. H. Gilliam, et al. (1981). Effects of nitrogen fertilization on Acer rubrum 'Red Sunset' grown in containers. Research Circular of the Ohio Agriculture Research Development Center(263): 14-16.
Abstract: The response of container grown Acer rubrum 'Red Sunset' to three nitrogen levels applied from June to September was studies. Trees fertilized at 150 and 300 ppm N exhibited a second growth flush. Tissue analysis of mature and immature leaves indicated that trees fertilized with 300 ppm N contained higher N concentrations. Fall color of plants fertilized with 50 ppm N was fully developed 3 weeks before plants that received 300 ppm N. Subsequent growth the following spring was significantly greater on trees fertilized with 300 ppm N.

(141) Hathaway, R. D. and C. E. Whitcomb (1976). Nutrition of container grown tree seedlings [Quercua shumardi, Betula nigra, Pinus thunbergi, Carya illinoensis, propagation]. Res-Rep-P-Okla-Agric-Exp-Stn(741): 41-45.

(142) Whitcomb, C. E. (1979). Effects of micromax micronutrients and osmocote on growth of tree seedlings in containers. Res Rep P Okla Agric Exp Stn(791): 42-44.

(143) Whitcomb, C. E. (1980). The carryover effect of micronutrients in container production. Proc-S-N-A-Res-Conf-Annu-Rep-South-Nurserymen's-Assoc: 52-54.

(144) Wallach, D., P. Loisel, et al. (1990). Modeling the time dependence of nitrogen uptake in young trees. Agron J 82(6): 1135-1140.
In order to develop improved fertilization strategies for fruit trees, it is necessary to have a quantitative understanding of the dynamics of N uptake. This study was conducted to select a mathematical model for describing N uptake in young peach trees (Prunus persica (L.) Batsch). In 1985 young peach trees were grown outdoors in Avignon, France, in sand-filled containers from late February to late September. At each of nine dates total tree N was measured by destructive sampling of three trees. The differences in total N between dates are related to N uptake. The models considered all take the form of a Michaelis-Menten equation, with maximum uptake expressed as the product of total root weight and uptake efficiency. The models differ in that they express the efficiency factor as different order polynomial functions of time. The criterion used for selecting a best model was related to the squared error of prediction integrated over time. The value of the criterion was estimated for each model, and it was found that the model that expressed efficiency as a third-order polynomial function of time had the smallest value of the criterion, and was therefore the model of choice. According to this model, N uptake efficiency increased from near zero in mid-April to a maximum of 3.1 microgram N/g root/d in late May, and then decreased again to near zero in late September.

(145) Emino, E. R., J. B. Storey, et al. (1980). Enhanced zinc uptake by container-grown shrubs with applications of nitrogen zinc nitrate solution. Hortsci 15(1): 93-94.
Nitrogen zinc nitrate solution was applied to 18 species of container-grown woody ornamentals to determine if Zn levels could be increased and related to increased growth and plant quality. In 13 species there was an increase in Zn concentration as compared to untreated plants. Quality was improved in 3 species without a related increase in Zn content. Fe and Mn concentrations were unaffected in most species and no phytotoxicity was observed.

(146) Cox, D. A. (1993). Reducing nitrogen leaching-losses from containerized plants: the effectiveness of controlled-release fertilizers. Journal of Plant Nutrition 16(3): 533-545.
To evaluate the effectiveness of controlled-release fertilizer (CRF) for reducing nitrogen (N) leaching-losses from containerized greenhouse crops, three experiments were conducted where CRFs were applied in different ways and compared to water-soluble fertilizer (WSF). In each experiment, 'First Lady' marigold (Tagetes erecta L.) plants in 0.5-liter pots of a soilless growth medium were fertilized with the same amount of N from 20N-4.3P-16.6K WSF, Osmocote 14N-6.2P-11.6K CRF, or Nutricote 14N-6.2P-11.6K CRF fertilizers. The volume of irrigation water applied to all treatments was the same in each experiment. Nitrogen content, as NH4-N and NO3-N in container leachates, and plant growth were measured and used to compare WSF with CRFs incorporated in the growth medium, or as applied to the surface, in either one large application or two small doses. A single large

application of CRF at planting resulted in as much or more N leaching than the regular application of WSF. Effectiveness of CRFs in limiting N leaching was greatly increased by making two smaller applications, the first at planting and the second 15 to 35 days later. More N was recovered in the leachate when CRFs were incorporated in the growth medium compared to surface application. Regardless of fertilizer type, application method, timing of application, or for each individual experiment, NO3-N was the predominant N form found in the leachate and more than one-half of the total amount of N leached during each experiment was recovered within 30 days of planting.

(147) Neilsen, G. H., D. S. Stevenson, et al. (1989). . . effect of municipal wastewater irrigation and rate of N fertilization on petiole composition, yield and quality of Okanagan Riesling grapes. Canadian Journal of Plant Science 69(4): 1285-1294.
Okanagan Riesling (Vitis sp.) vines, planted on a sandy soil in 1983, were trickle irrigated with municipal wastewater or well water and with each source of water there were 3 rates of N fertilization (0, 17, and 34g N as NH4NO3 vine -1y-1), 1984-1987. The zero N treatment was increased to 8.5 g N vine-1 in 1986-1987. Wastewater-irrigated vines had increased petiole P, K and Ca but decreased Mg and in 2 of 3 yr. decreased N in August. Increased rate of N fertilization increased petiole N at bloomtime but Mn at highest N rates, especially (2 of 4 yr.) in association with wastewater irrigation. Yield increased both for vines irrigated with wastewater and linearly with rate of applied N in 2 of the 3 fruiting years. Increased yield was not associated with increased petiole N concentration in August. Minor increased in soluble solids and juice pH of grapes at harvest were measured for wastewater-irrigated grapes in 2 yr. No horticultural limitations to the use of this wastewater to irrigate Okanagan Riesling grapes were observed over the 4 year period.

(148) Murray, C. L., G. P. Lumis, et al. (1996). Fertilizer method and container size effects on shade trees grown in in-ground containers. Can j plant sci 76(3): 507-513.

(149) Greenwell, B. R. (1982). Use of Osmocote in container growing Slow-release fertilizers, ornamental nursery plants and trees. Comb Proc Int Plant Propagators Soc 31: 85-88.

(150) Kuhns, L. J. (1987). Fertilizing woody ornamentals. Ext Circ Pa State Univ Agric Ext Serv(353): 16.

(151) Wenny, D. L. (1989). LOTUS 123 template for nutrient calculation. Tree Plant Notes U S Dep Agric For Serv 40(2): 5-7.
A template for Lotus 123 calculates macronutrients and micronutrients in parts per million (ppm) for given fertilizer combinations. The difference between applied nutrient rate and target level for each nutrient is calculated. The effect of change in application rate can be instantly determined.

(152) Kiehl, P. A., J. H. Lieth, et al. (1992). Growth response of chrysanthemum to various container medium moisture tension levels. Journal for the American Society of Horticulture Science 117(2): 224-229.
A computer-controlled drip irrigation system was used to implement three types of moisture regimes in the potting medium of container-grown chrysanthemum [Dendranthema X grandiflorum (Ramat.) Kitamura] plants: "constant" moisture tension treatments were maintained by setting low- and high-tension set-points to the same value; "variable" tension treatments were imposed by setting the low- and high-tension set-points to 2 and 7 kPa, respectively; "timed" irrigation consisted of irrigating once per day for a fixed (excessive) duration that resulted in fluctuations in tension ranging from 0 to 10 kPa. Constant moisture tension conditions in the range of 0.8 to 16 kPa showed decreasing fresh and dry weight patterns with increasing tension, decreasing average moisture content, decreasing amounts of applied irrigation solution, and, consequently, with decreasing amounts of nutrients applied. Plants grown under conditions where the moisture content fluctuated appreciably (variable and timed) tended to be larger than those grown within the narrow tension ranges (constant); for the latter, optimal plant growth occurred at the lowest tension (0.8 kPa) and highest average moisture content (71%). For fluctuating conditions, the control (with the widest fluctuations) had the highest dry weight growth. The variable tension treatments, while resulting in average moisture tensions of 4.4 to 4.9 kPa, resulted in plant growth similar to plants grown at constant low tension (0.8 to 1.6 kPa), rather than those grown at tensions between 4 and 5 kPa.

(153) Gilman, E. F., G. W. Knox, et al. (1994). Microirrigation affects growth and root distribution of trees in fabric containers. HortTechnology 4(1): 43-45.
Lagerstroemia indica L. x fauriei Koehne ('Natchez' crape myrtle) crown width increased after 13 months as irrigation frequency increased from every 3 days to every day, and the irrigated area around the fabric container increased from 20% to 100% of the circular area within 20 cm beyond the container. Restricting irrigation to within the fabric container plus 20% of the area 20 cm beyond the container edge resulted in less height and width for crape myrtle, but had no effect on root growth, compared to irrigating 100% of area 20 cm beyond the container. Restricting the pattern of irrigation to the container plus 20% of the area 20 cm beyond the container resulted in greater fine-root weight (roots<5 mm in diameter) within the container for laurel oak (Quercus laurifolia Michx.) compared to irrigating the container plus 100% of the area 20 cm beyond the container. Height, width, and caliper of oak were not different among treatments.

(154) Eakes, D. J., C. H. Gilliam, et al. (1985). Influence of trickle irrigation on six field-grown woody landscape species based on new evaporation. Journal of Environmental Horticulture 3(3): 139-142.
Six woody landscape species were field-grown with 4 irrigation rates based on 0%, 25%, 50%, and 100% replacement of net evaporation from a class A pan. Optimum irrigation rates varied by species. Japanese holly 'Petite Point' (Ilex crenata 'Petite Point'), flowering dogwood (Cornus florida), green ash (Fraxinus pennsylavanica), and river birch (Betula nigra) had greater growth when irrigated compared to non-irrigated plants. Increases in caliper due to trickle irrigation occurred during the second growing season for 3 tree species. Growth of Pyrus calleryana ('Bradford' pear) and pin oak (Quercus palustris) was similar regardless of irrigation rates. Only 'Petite Point' Japanese holly had improved livability as a result of trickle irrigation.

(155) Prevatt, J. W., G. A. Clark, et al. (1992). A comparative cost analysis of vegetable irrigation systems. HortTechnology 2(1): 91-94.
Three vegetable irrigation systems, semi-closed subirrigation, fully enclosed subirrigation, and drip irrigation, were evaluated for use on sandy soils with naturally high water tables to determine comparative irrigation costs for tomato production. Investment, fixed (ownership), and variable (operating) costs were estimated for each irrigation system. The investment costs of the drip irrigation system were significantly greater than those for the semi-closed and fully enclosed irrigation systems. The variable costs, however, for the semi-closed system were considerably less than those for the fully enclosed and drip irrigation systems. The semi-closed irrigation system, therefore, was determined to the least-cost tomato irrigation system under present fuel cost and

nonlimiting water supply conditions.

(156) Yeager, T., R. Wright, et al. (1993). Six state survey of container nursery nitrate nitrogen runoff. Journal of Environmental Horticulture 11(4): 206-208.
Container nursery bed runoff, reservoirs or ponds that contained runoff, wells, and surface water discharged from the property or at the property border were sampled at approximately 6-week intervals during April-October 1990 in Alabama, Florida, New Jersey, North Carolina, Ohio and Virginia. Runoff from container beds averaged 8 and 20 ppm NO3-N, respectively, for nurseries using controlled-release fertilizers (CRF) and controlled-release fertilizers supplemented with solution fertilizers (CRFSS). Average NO3-N levels for runoff collections pods, property borders, and wells were each less than 10 ppm, the drinking water limit, regardless of fertilizers used. However, ppm NO3-N for some samples exceeded the drinking water standard. In general, these data indicate reason for concern and nursery operators need to implement best management practices.

(157) Maust, B. E. and J. G. Williamson (1992). Nitrogen rate effect on growth of containerized citrus nursery plants. Proc annu meet Fla State Hort Soc 104: 191-195.
Container solution levels of nitrogen required to optimize growth of containerized citrus nursery plants, while minimizing nitrogen loss through leaching, were determined. Carrizo citrange [citrus sinensis (L.) Osb. x Poncirus trifoliata (L.) Raf.] and Cleopatra mandarin [Citrus reticulata Blanco] seedlings, budded with 'Hamlin' orange [Citrus sinensis (L.) Osb.], were grown in a greenhouse in 2 liter plastic containers in washed sand media. In experiments 1 and 2, the plants received one liter daily of either 0, 12.5, 25, 50, 100, or 200 ppm of N as NH4NO3 dissolved in a complete nutrient solution. In experiment 3, they received either 0, 3.13, 6.25, 12.5 or 50 ppm N as NH4NO3. Shoot length and leaf area of the second and third scion flush, total shoot length, and total leaf area increased as nitrogen levels increased up to a critical level but leveled off above the critical level. The critical container solution nitrogen level was between 15 and 20 ppm. Root, shoot, and total dry weights increased as nitrogen levels increased up to this critical level with no further increases at higher nitrogen levels. Results from this study suggest that nitrogen fertilization levels lower than those normally applied in commercial citrus nurseries may be adequate for optimal growth of container-grown citrus nursery plants.

(158) Burkart, M. R. and D. W. Kolpin (1993). Hydrologic and land-use factors associated with herbicides and nitrate in near-surface aquifers. J environ qual 22(4): 646-656.
Selected herbicides, atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine) metabolites, and NO_3- were examined in near-surface unconsolidated and bedrock aquifers in the midcontinental USA to study the hydrogeologic, spatial, and seasonal distribution of these contaminants. Groundwater samples were collected from 303 wells during the spring and late summer of 1991. At least one herbicide or atrazine metabolite was detected in 24% of the samples collected for herbicide analysis (reporting limit 0.05 micrograms/L). No herbicide concentration exceeded the USEPA's maximum contaminant level (MCL) or health advisory level. The most frequently detected compound was the atrazine metabolite deethylatrazine.

(159) Brand, M. H., R. J. McAvoy, et al. (1993). Nitrate loading to the soil profile underlying two containerized nursery crops supplied controlled release fertilizer. Journal of Environmental Horticulture 11(2): 82-85.
Cornus amomum and Rhododendron 'Cary's Red' were grown in #3 (10 l) containers outdoors and supplied with a controlled release fertilizer (CRF). At two-week intervals, core samples were removed from the soil underlying the crop at 30 cm (12 in) increments to a depth of 90 cm (36 in). Soil samples and foliar samples were analyzed for nitrate nitrogen (NO3-N) concentration. NO3-N accumulated rapidly in the upper 30 cm (12 in) of soil underlying containerized crops. Accumulation in the 30-60 cm (12-24 in) layer occurred later in the growing season and NO3-N buildup in the 60-90 cm (24-36 in) layer lagged behind both upper soil layers. Maximum NO3-N concentrations exceeded 40 mg/kg (6.36 x 10 -4 oz lb-1) of soil and levels above 20 mg/kg (3.18 x 10-4 oz/lb.) of soil were sustained throughout the 90 cm (36 in) soil profile for much of the growing season. Patterns of soil NO3-N concentration suggest that, by the middle of the growing season, rapid-growing Cornus may better utilize released N fertilizer than slower growing Rhododendron. Foliar samples confirm significantly higher NO3-N uptake by Cornus than by Rhododendron.

(160) Remphrey, W. R. and C. G. Davidson (1996). The effect of nitrogen on growth and architecture of Fraxinus pennsylvanica 'Patmore' (green ash) in field-grow containers at two sites in Manitoba, Canada. Can j plant sci 76(4): 825-833.
Fraxinus pennsylvanica var. subintegerrima (Vahl) Fern. 'Patmore' green ash was established at two sites in southern Manitoba. Four levels of N fertilizer (4.5-400) ppm were applied during two growing seasons. Growth and development of the trees was dependent on the site and local environmental conditions. At Morden, the annual height growth increment was greater with lower levels of N applications and declined at higher levels, while at Winnipeg higher levels resulted in greater growth. Stem diameter changes followed a similar pattern. The numbers of lateral shoots per parent shoot were only weakly affected by N treatment and any differences appeared to be an indirect effect of parental shoot length. The Field-grow containers at the Winnipeg site were installed in grass-sod which penetrated the containers and appeared to result in competition for N resources. The Morden site was kept cultivated and thus there was so such competition. A Morden, it is possible that wicking from the surrounding soil may have moved excessive salts into the containers resulting in high conductivity values and toxicity.

(161) Harrington, J. T. and P. A. Glass (1998). MACRONUT: calculation software for custom-mixed nursery fertilizers. HortTechnology 8(1): 78-81.
MACRONUT, a software program for microcomputers, calculates mixing rates of 17 commonly used nutrient sources of six mineral macronutrients for custom-mixed fertilizers. The software alleviates the need for the cumbersome calculations required to develop or adjust custom mixed fertilizers. The software can be used by field professionals and as an instructional tool for teaching horticultural students how to develop custom fertilizers for container nursery crops.

(162) Cole, J. C. and J. M. Dole (1997). Temperature and phosphorus source affect phosphorus retention by a pine bark-based container medium. HortScience 32(2): 236-240.
These studies were conducted to determine the effect of 1) temperature on P leaching from a soilless medium amended with various P fertilizers, 2) water application volume on P leaching, and 3) various fertilizers on P leaching during production and growth of marigolds (Tagetes erecta L. 'Hero Flame'). Increasing temperature linearly decreased leaching fraction; however, total P leached from the single (SSP) or triple (TSP) superphosphate-amended medium did not differ regardless of temperature. Despite a smaller leaching fraction at higher temperatures and no change in the total P leached, P was probably leached more readily at higher temperatures. More P was leached from the medium

amended with uncoated monoammonium phosphate (UCP) than from the medium containing polymer-coated monoammonium phosphate (CTP) at all temperatures, and more P was leached from UCP-amended medium at lower temperatures than at higher temperatures. More P was leached from TSP- than from SSP-amended medium and from UCP- than from CTP-amended medium regardless of the water volume applied, but leachate P content increased linearly as water application volume increased for all fertilizers tested. Plant dry weights did not differ regardless of P source. Leachate electrical conductivity (EC) was lower with TSP than with SSP. Leachate EC was also lower with CTP than with UCP. A higher percentage of P from controlled release fertilizer was taken up by plants rather than being leached from the medium compared to P from uncoated fertilizers.

(163) Whitcomb, C. E. and B. L. Appleton (1983). Effects of topdressing container nursery stock on root development following transplanting [Pyracantha]. Res Rep P Agric Exp Stn Okla State Univ(843): 68.

(164) Swiader, J. M., J. G. Sullivan, et al. (1988). Nitrate monitoring for pumpkin production on dryland and irrigated soils. Journal for the American Society of Horticulture Science 113(5): 684-689.
Field experiments were conducted in 1985 and 1986 to determine in-season indexes for petiole NO3-N in dryland-grown and irrigated pumpkins (Cucurbita moschata Poir.). The level of NO3-N in petioles of recently mature leaves was a good indicator of the seasonal N status for pumpkins on irrigated sand, and to a lesser degree for pumpkins on dryland loam. Petiole NO3-N concentrations decreased with time and with decreasing N rate at both sites, with the rate and extent of decrease considerably greater on the irrigated sand. The optimum time of sampling was at about initial fruit set or early fruiting. Critical (10% yield reduction) and minimum sufficiency (lowest concentration before yield reduction) levels for petiole NO3-N at early fruiting were estimated at 6300 and 8000 micrograms.g-1, respectively, in dryland and 4000 and 6700 micrograms.g-1, respectively, for irrigated plantings. Deficiency symptoms were associated with NO3-N concentrations less than 1500 micrograms.g-1. Soil NO3-N levels proved unsatisfactory as a NO3-N index in dryland soil, but meaningful relationships (R2 = 0.31) were obtained between fruit yield and soil NO3-N on irrigated sand. Fertilizer N requirements for 90% and 100% of marketable yield were estimated at 44 and 158 kg N/ha for dryland and 125 and 225 kg N/ha for irrigated pumpkins, respectively. However, N fertilizer rates of 202 and 269 kg N/ha delayed harvest 9 days on irrigated sand and 15 days on dryland loam, compared to lower N rates.

(165) Coltman, R. R. (1988). Yields of greenhouse tomatoes managed to maintain specific petiole sap nitrate levels. HortScience 23(1): 148-151.

(166) Oosterhuis, D. M., O. Abaye, et al. (1994). A summary of a three-year beltwide study of soil and foliar fertilization with potassium nitrate in cotton. Proc Beltwide Cotton Conf 3: 1532-1533.

(167) Panikar, S. N. and M. Raghunath (1974). Foliar feeding: a powerful tool in development of high produ ctivity technology in agriculture. Farm Journal Calcutta 15(6): 21-24.

(168) Davey, P. C. (1973). The facts on foliar feeding [Plant nutrition]. Farmer's News 121: 3-4,6.
The use of foliar nutrient sprays has increased over the past few years in horticultural plantings of the M.J.A. and many growers wish to know theory behind the use of the foliar nutrient sprays and the advantages and disadvantages of using these sprays.

(169) Mandal, G., V. S. Chhonkar, et al. (1978). Soil and soil-cum-foliar feeding of NPK nitrogen, phosphorus, potassium on growth and yield of onion (Allium cepa L.). Coimbatore, South Indian Horticultural Association. 26(1): 18-21.

(170) Shrothiya, G. C. and G. S. Chundawat (1972). Foliar fertilization of urea--few tips worth knowing. Farmer Parliament 7(5): 25-27.

(171) Smith, F., N. Malm, et al. (1987). Timing and rates for nitrogen foliar fertilization of cotton. Proceedings Beltwide Cotton Producers Research Conference, Memphis Tennessee: National Cotton Council and the Cotton Foundation: 61-62.
Foliar timing and rate experiments were conducted to evaluate the response of foliar applied nitrogen on lint yield and fiber quality of Acala cotton (Gossypium hirsutum). In the timing study, urea was foliar applied at 5 lbs N/A on July 15 and 30, and August 15 and 30. The highest yielding foliar combination was produced with the July 15 and August 15 spray dates. The three highest yielding foliar combinations all had an August 15 application date. Generally, the highest yields were associated with the early and mid-seasonal applications. In the rate study, urea and a commercial blend of 12-6-6 generally had a positive affect on yield. Uran caused foliage burn that reduced yields.

(172) McDole, R. E. (1977). Foliar fertilizer trials on potatoes. Proceedings Annual Northwest Fertility Conference 28: 101-107.

(173) Soltanpour, P. N. (1973). Foliar feeding of potato plants with urea. Colorado Agricultural Experiment Station Progress Report Pr.: 73-29 2p.

(174) Gilliam, C. H. and E. M. Smith (1980). Fertilization of container-grown nursery stock. Bulletin Cooperative Extension Service Ohio State University(658): 18.

(175) Murakami, P., T. H. H. Chen, et al. (1990). Desiccation tolerance of deciduous plants during postharvest handling. Journal of Environmental Horticulture 8(1): 22-25.
Nurserymen consider Washington hawthorn (Crategus phaenopyrum Med.) sensitive and Norway maple (Acer platanoides L.) tolerant to postharvest practices. The desiccation tolerance, cold hardiness and water potential at various growth stages were monitored on field-grown Washington hawthorn and Norway maple. There were no differences between these two species in the rate of water loss in the root, shoot or whole plants. Hawthorn, however, was more sensitive to desiccation stress than maple throughout all growth stages. The roots lost water at a faster rate than the stems in both species. Hawthorn plants acquired rest and cold hardened later in the fall and attained less dormancy and less freezing tolerance than did maple.

(176) Whitcomb, C. E. (1983). Why large trees are difficult to transplant. Journal of Arboriculture 9(2): 57-59.
Southern magnolia trees from 1 to 5 inch stem diameter were evaluated for total stem surface area. The square inches of stem surface area show that a one inch diameter magnolia has approxiamately 580 square inches whereas a 3 inch tree has 5,200 square inches and a 5 inch tree has in excess of 25,000 square inches. This emphasizes the importance of stored carbohydrate reserves in the stems and roots prior to transplanting. The larger the tree the more critical the stored reserves and the demand for stored reserves immediately following transplanting. A schematic diagram of the sequence of events following transplanting is included.

(177) Faulkner, S. P. (1998). Greenhouse Math: Thinking in parts per million. Growing Edge ?(?): 68-70.

(178) Welker, W. V., Jr. and D. M. Glenn (1988). Growth responses of young peach trees and changes in soil characteristics with sod and conventional planting systems. Journal of American Society of Horticulture Science 113(5): 652-656.
Peach (Prunus persica (L.) Batsch) trees were planted in four soil management systems (cultivated, herbicide, mowed sod, and killed sod) in 1982 and grown through 1984. A companion study was established in 1984 with three systems (cultivated, herbicide, and killed sod). Tree growth and fruit yield were greatest when trees were planted and managed in a killed sod system. Establishing a living sod before planting the trees, and then killing the sod with herbicides, prevented the depletion of soil organic matter and increased water infiltration rates, aggregate stability, macroporosity, and microbial respiration rates compared to conventional systems. The changes in soil structure persisted for 2 to 3 years.

(179) Stivers Young, L. (1998). Growth, nitrogen accumulation, and weed suppression by fall cover crops following early harvest of vegetables. HortScience 33(1): 60-63.
Oats (Avena sativa L.), phacelia (Phacelia tanacetifolia Benth.), oilseed radish (Raphanus sativus L.), white senf mustard (Brassica hirta Moench), kale (Brassica oleracea L.), canola (Brassica napus L.), turnip (Brassica rapa L.), and yellow mustard (Brassica hirta Moench) were evaluated for their ability to grow accumulate leachable N, and suppress winter annual weeds during the fall following early harvest of vegetables in the northeastern United States. Brassica and phacelia cover crops planted in late August and early September produced 3000-4000 kg.ha(-1) in aboveground biomass, and took up 100-120 kg.ha(-1) soil N before winter killing in December. Soil inorganic N decreased in all plots through the fall of both years but concentrations in cover crop plots tended to be lower than in bare plots. Analysis of soil surface residues the following April showed that brassicas had lost a greater proportion of aboveground biomass and N during the winter than had oats in 2 years of study. How much of the loss of biomass was due to residue decomposition at the soil surface and how much was due to wind or other off-site losses is not clear. Soil inorganic N concentrations in cover crop plots tended to be higher than in bare plots the following April. Cover crop residues significantly suppressed weed growth in early spring; in several treatments, no measurable weed growth was found in the second year. These results indicate that oilseed radish, white senf mustard, and yellow mustard are well suited for use as fall cover crops in the temperate northeastern United States, but that significant biomass and N may be lost if they are left to winter kill.

(180) Cabrera, R. I. (1997). Using slow- and controlled- release fertilizers in container nursery crops, Rutgers University, New Jersey.

(181) Greenwell, B. R. (1980). Osmocote and minor element formulations and rates for growing nursery stock in containers. Ornamentals Northwest Newsletter Cooperative Extension Service Oregon State University 4(4): 6-8.

(182) Wright, R. D. and A. X. Niemiera (?). Nutrition of container-grown woody nursery crops. Horticultural Reviews 9: 75-101.

(183) Maynard, D. N. and O. A. Lorenz (?). Controlled-release fertilizers for horticultural crops. Horticultural Reviews 1: 79-140.

(184) Ogden, R. J., F. A. Pokorny, et al. (?). Elemental status of pine bark-based potting media. Horticultural Reviews 9: 103-131.

(185) Jones, J. B., Jr. (1985). Soil testing and plant analysis: guides to the fertilization of horticultural crops. Horticultural Reviews 7: 1-68.

(186) Merwin, I. A. and W. C. Stiles (1994). Orchard groundcover management impacts on apple tree growth and yield, and nutrient availability and uptake. Journal of American Society for Horticultural Science 119(2): 209-215.
This study compared various conventional and alternative orchard groundcover management systems (GMSs)--including a crownvetch "living mulch" (CNVCH), close-mowed (MWSOD) and chemically growth-regulated (GRSOD) sodgrasses, pre-emergence (NDPQT) and two widths of postemergence (GLY1.5 and GLY2.5) herbicides, hay-straw mulch (STMCH), and monthly rototillage (tilled)-during 6 years in a newly established apple (Malus domestica Borkh.) planting. Trunk cross-sectional area and fruit yield were higher in STMCH, GLY, and NDPQT, intermediate in tilled, and lower in GRSOD, MWSOD, and CNVCH treatments after 5 years. Despite N and K fertilizer applications, extractable soil N and leaf N concentrations were reduced under MWSOD and GRSOD, and soil K, P, and B concentrations were greater under STMCH. Leaf K concentrations were usually highest in STMCH trees, even when heavily cropped; leaf K declined below the sufficiency range in GLY, NDPQT, and tilled trees as they began to bear fruit. Leaf Ca was marginally deficient in all trees and was unaffected by GMS. Foliar Mn, Zn, and B concentrations declined rapidly in all treatments during 2 years without micronutrient fertilizers. Leaf Cu was higher in herbicide and tilled treatments where seasonal soil water content was intermediate (22% to 27%) and lower where soil was very wet or dry for most of the 1988 growing season. Multiple regression analysis indicated that leaf N and B and soil organic matter in 1990, and mean soil water content during the unusually dry Summer 1988, were the best predictors of fruit yield in 1990. Phytophthora root rot and meadow vole depredation were serious problems in STMCH and CNVCH trees. GMSs greatly affected tree establishment.

(187) Merwin, I. A., W. C. Stiles, et al. (1994). Orchard groundcover management impacts on soil physical properties. Journal of American Society for Horticultural Science 119(2): 216-222.
This study was conducted to compare various orchard groundcover management systems (GMSs)--including a crownvetch "living mulch" (CNVCH), close-mowed (MWSOD) and chemically growth-regulated (GRSOD) sodgrasses, pre-emergence (NDPQT) and two widths of post-emergence (GLY1.5 and GLY2.5) herbicides, hay-straw mulch (STMCH), and monthly rototillage (tilled)-during the first 6 years in a newly established apple (Malus domestica Borkh.) planting. Mean soil water potential at 5 to 35 cm deep varied substantially among treatments each summer, and treatment X year interactions were observed. During most growing seasons from 1986 to 1991, soil water availability trends were STMCH > NDPQT > GLY2.5 > GLY1.5 > tilled > GRSOD > MWSOD > CNVCH. Soil organic matter content increased under STMCH, CNVCH, and MWSOD and decreased under NDPQT and tilled treatments. Water infiltration and saturated hydraulic conductivity after 4 years were lower under NDPQT and tilled, and soil under STMCH and GRSOD retained more water per unit volume at applied pressures approximating field water capacity. Mid-summer soil temperatures at 5 cm deep were highest (25 to 28C) in tilled and NDPQT plots, intermediate (22 to 24C) under GRSOD, and lowest (16 to 20C) under CNVCH and STMCH. These observations indicate that long-term soil fertility and orchard productivity may be diminished under pre-emergence

herbicides and mechanical cultivation in comparison with certain other GMSs.

(188) Arnold, M. A. and D. K. Struve (1989). Green ash establishment following transplant. Journal of American Society for Horticultural Science 114(4): 591-595.
Bare-root 1-year-old green ash (Fraxinus pennsylvanica Marsh.) seedlings were transplanted into root observation boxes under greenhouse conditions to study timing of budbreak, root regeneration, and subsequent shoot growth during establishment. Green ash seedlings began shoot growth before root growth. Seven to 20 days after transplant, intact second- and third-order lateral roots (referred to here after as intact roots) began to elongate, followed 10 to 19 days later by initiation of long roots from callus at pruned root surfaces. Plants with earlier budbreak were larger and regenerated more roots faster than plants that broke bud later. During establishment, there was a strong correlation between shoot and intact root elongation and a low correlation between shoot and long root elongation. Root pruning after establishment resulted in bud set and/or cessation of shoot elongation within 3 to 6 days in 1985 and within 20 to 28 days in 1986. The days to bud set and cessation of shoot elongation were positively correlated with increased numbers of regenerated roots from pruned surfaces (long roots). Only long root elongation was significantly correlated with shoot growth after root pruning. Root pruning also induced reductions (12 days) in net photosynthesis, transpiration, and stomatal conductance, and increased stomatal resistance to water loss; however, all recovered after root regeneration.

(189) Englert, J. M., K. Warren, et al. (1993). Antidesiccant compounds improve the survival of bare-root deciduous nursery trees. Jouranal of American Society for Horticultural Science 118(2): 228-235.
Desiccation stress during the postharvest handling of bare-root deciduous trees can account for dieback and poor regrowth after transplanting. Desiccation tolerance of three bare-root deciduous hardwood species was determined at monthly harvest intervals from Sept. 1990 through Apr. 1991. Among the three species tested red oak (Quercus rubro L.) was most tolerant to desiccation, followed by Norway maple (Acer platanoides L.) and Washington hawthorn (Crataegus phaenopyrum Medic.). Maximum desiccation tolerance of all three species occurred during the January and February harvests. Of 20 film-forming compounds tested, the antidesiccant Moisturin was the most effective in reducing water loss from bare-root trees during desiccation stress and in improving survival and plant performance during re-establishment in the laboratory, greenhouse, and field. Moisturin-treated plants lost up to 80% less water than untreated plants. Washington hawthorn seedlings treated with Moisturin before severe desiccating conditions had the highest survival, lowest dieback/plant, and highest root growth ratings. The results indicate that Moisturin is an effective means of overcoming postharvest desiccation stress in desiccation sensitive plants, such as Washington hawthorn.

(190) Rowland, L. J., A. Levi, et al. (1995). Progress toward identifying markers linked to genes controlling chilling requirement and cold hardiness in blueberry. Journal of Small Fruit and Viticulture 3(2/3): 39-52.

(191) Kasperbauer, M. J. (1992). Phytochrome regulation of morphogenesis in green plants: from the Beltsville Spectrography to colored mulch in the field. Photochemistry and Photobiology 56(5): 823-832.
Development of the theory and use of photon ratios reflected from colored mulches to regulate plant morphogenesis in the field utilized information obtained on the Beltsville Spectrograph, in controlled environments and in field plant spacing studies. An upwardly reflected far-red to red (FR/R) ratio higher than the ratio in incoming sunlight resulted in larger shoots and a higher shoot/root biomass ratio. A reflected FR/R ratio lower than the ratio in incoming sunlight resulted in larger roots and a lower shoot/root biomass ratio.

(192) Shen, W. H. and C. Gigot (1997). Protein complexes binding to cis elements of the plant histone gene promoters: multiplicity, phosphorylation and cell cycle alteration. Plant Molecular Biology 33(3): 367-379.
The S phase-specific expression of histone genes provides an interesting model for studying activation of gene transcription during the cell cycle. In plants, however, trans-acting factors responsible for histone gene transcription are poorly documented. Using combined gel shift, UV cross-linking and competition analysis, we carried out a systematic study to identify and characterize proteins binding with the previously established cis elements of the plant histone gene promoters Nuclear extracts prepared from the highly synchronizable tobacco BY2 cells were used. We confirmed the presence of proteins binding to the hexamer (ACGTCA) motif which has been previously identified as the binding site of wheat HBP-1 proteins. Interestingly, multiple proteins were found to bind specifically with the nonamer (CAATCCAAC) element and their DNA-binding activity was abolished upon in vitro protein phosphatase treatment. This later result imply phosphorylation/dephosphorylation as a potential posttranslational control for DNA-binding activity of nonamer-binding proteins. In addition, the DNA-binding activity of these nonamer-binding proteins was found to be positively correlated with the S phase-specific expression of the histone genes in the synchronized cells, suggesting their function in the activation of transcription during the G1/S transition. Finally, several proteins were observed to bind specifically with an A/T-rich hexamer (TAATAT) motif. Their DNA-binding activity, however, was insensitive to phosphatase activity in vitro and relatively constitutive during the cell cycle. This A/T-rich hexamer as a new cis-acting element of plant histone genes is.

(193) Shen, W. H. and C. Gigot Protein complexes binding to cis elements of the plant histone gene promoters: multiplicity, phosphorylation and cell cycle alteration. Plant mol biol 33(3): 367-379.
The S phase-specific expression of histone genes provides an interesting model for studying activation of gene transcription during the cell cycle. In plants, however, trans-acting factors responsible for histone gene transcription are poorly documented. Using combined gel shift, UV cross-linking and competition analysis, we carried out a systematic study to identify and characterize proteins binding with the previously established cis elements of the plant histone gene promoters Nuclear extracts prepared from the highly synchronizable tobacco BY2 cells were used. We confirmed the presence of proteins binding to the hexamer (ACGTCA) motif which has been previously identified as the binding site of wheat HBP-1 proteins. Interestingly, multiple proteins were found to bind specifically with the nonamer (CAATCCAAC) element and their DNA-binding activity was abolished upon in vitro protein phosphatase treatment. This later result imply phosphorylation/dephosphorylation as a potential posttranslational control for DNA-binding activity of nonamer-binding proteins. In addition, the DNA-binding activity of these nonamer-binding proteins was found to be positively correlated with the S phase-specific expression of the histone genes in the synchronized cells, suggesting their function in the activation of transcription during the G1/S transition. Finally, several proteins were observed to bind specifically with an A/T-rich hexamer (TAATAT) motif. Their DNA-binding activity, however, was insensitive to phosphatase activity in vitro and relatively

constitutive during the cell cycle. This A/T-rich hexamer as a new cis-acting element of plant histone genes is.

(194) Falusi, M. and R. Calamassi (1990). Bud dormancy in beech (Fagus sylvatica L.). Effect of chilling and photoperiod on dormancy release of beech seedlings. Tree Physiololgy 6(4): 429-438.
Two-year-old Fagus sylvatica L. seedlings were subjected to natural winter chilling or were overwintered in a heated greenhouse. Plants were then grown in controlled environment chambers with photoperiods of 9 or 13 h. Renewal of bud growth was found to be mainly determined by chilling. There was a slight interaction between chilling and photoperiod. Sprouting of apical buds took two to three times as long in unchilled plants. Shoot elongation was influenced by chilling and was also greater in the 13-h photoperiod than in the 9-h photoperiod, but this may have been due at least in part to the higher irradiance. Chilling resulted in rapid dormancy loss and changed the growth pattern from basitonal to acrotonal.

(195) Burr, K. E., R. W. Tinus, et al. (1990). Comparison of three cold hardiness tests for conifer seedlings. Tree Physiology 6(4): 351-369.
Greenhouse-cultured, container-grown ponderosa pine (Pinus ponderosa var. scopulorum Engelm.), interior Douglas-fir (Pseudotsuga menziesii var. glauca (Beissn.) Franco), and Engelmann spruce (Picea engelmannii (Parry) Engelm.) were cold acclimated and deacclimated in growth chambers over 19 weeks. Cold hardiness was measured weekly by a whole-plant freeze test and by two quick tissue tests: freeze-induced electrolyte leakage of needles, and differential thermal analysis of buds. The whole-plant freeze test provided results in 7 days, and indicated differences in cold hardiness among stems, buds, and needles. Although the whole-plant freeze test could accurately measure cold hardiness, it was not precise, and it required destructive sampling. Results from freeze-induced electrolyte leakage and differential thermal analysis were available in 2 days and 1 hour, respectively. The freeze- induced electrolyte leakage test was a precise, sensitive and objective predictor of changes or differences in tissue cold hardiness. To determine actual cold hardiness, results could be calibrated to the response of the same tissue in the whole-plant freeze test. The speed and objectivity of differential thermal analysis made this test useful for rapid, general assessment of cold hardiness status, but calibration was difficult, and precision varied.

(196) Creamer, N. G., M. A. Bennett, et al. (1997). Evaluation of cover crop mixtures for use in vegetable production systems. HortScience 32(5): 866-870.
Planting polyculture mixtures of cover crops can optimize the benefits of their use. Thirteen polyculture mixtures of cover crops were evaluated in Columbus and Fremont, Ohio, to find a species mix that would establish quickly for erosion control, overwinter in Ohio, contribute sufficient N and have a C : N ratio between 20:1 and 30:1 to optimize N availability for subsequent crops, be killable by mechanical methods, and have high weed control potential. All of the mixtures in Columbus had achieved 30% ground cover 1 month after planting, but only four of the mixtures achieved this in Fremont due to poor conditions at planting. Above-ground biomass (AGB) accumulation in the mixtures ranged from 3631 to 13,642 kg.ha-1 in Columbus, and 449 to 12,478 kg.ha-1 in Fremont. Nitrogen in the AGB ranged from 74 to 269 kg.ha-1 in Columbus, and 10 to 170 kg ha-1 in Fremont. Weed cover in the cover crop plots ranged from 1% to 91% eight weeks after cover crop kill in Columbus, and 12% to 90% seven weeks after cover crop kill in Fremont. Because one or more species in each screened mixture was determined not to be suitable, none of the mixtures was optimum. However, information gained about performance of individual species within the mixtures is also useful. 'Nitro' alfalfa (Medicago sativa L.), ladino clover (Trifolium repense L.), subterranean clover (Trifolium subterraneum L.), Austrian winter peas [Pisum sativum ssp. Arvense (L.) Poir], and annual ryegrass (Lolium multiflorum Lam.) did not overwinter dependably in Ohio. Tall fescue (Festuca arundinacea L.), perennial ryegrass (Lolium perenne L.), and orchardgrass (Dactylis glomerata L.) did not compete well with.

(198) Robinson, J. B. and M. G. McCarthy (1985). Use of petiole analysis for assessment of vineyard nutrient status in the Barossa district of South Australia. Australian Journal of Experimental Agriculture 25(1): 231-240.
A study of the petiole nutrient status of cvv. Shiraz, Cabernet Sauvingnon and Rhine Riesling (Vitis vinifera) was carried out in 19 vineyards of each in the Barossa Valley, South Australia, during 1979 to 1982. The sampling unit chosen was the petiole of leaves opposite bunches, collected at flowering time. Nitrogen status (assessed as nitrate concentration) varied widely among vineyards and high concentrations of nitrate could be associated with use of organic materials (chicken litter, winery marc) in vineyards. Phosphorous status was almost invariably higher than necessary. Potassium, magnesium and chloride status were usually high by Californian standards. Of the trace elements, boron was low in 1979 to 1980 in some vineyards, but sufficient in other years. Zinc and manganese were usually present in sufficient quantities. Daily sampling of petioles showed that nutrient levels during the flowering period changed less dramatically in this region than in California. Pre-bloom foliar sprays of urea with zinc had non-significant effects on petiole nitrate concentration. Differences in nutrient concentrations between the three cultivars were detected in some years. The standards used to interpret petiole analysis data in California, while useful in the survey area required some modificatrion for local use, and working standards are proposed.

(199) Aiello, A. S. and W. R. Graves (1998). Container medium and nitrogen form affect production of Amur maackia (Maackia amurensis Rupr. & Maxim.). HortTechnology 8(2): 261.
Amur maackia (Maackia amurensis Rupr. & Maxim.) has potential as a more widely grown nursery crop, but little information is available on effects of media and nutrition on growth of containerized plants. We compared growth of seedlings in five media and determined growth responses to two fertility regimes. After 35 days, total dry mass of plants grown in 1 perlite: 1 vermiculite (by volume) or in 5 sphagnum peat: 3 perlite: 2 soil was 3.2 times the dry mass of plants grown in three soilless media that contained composted bark; and after 70 days, growth was greater in the medium with soil than in 1 perlite: 1 vermiculite. Plants grown in solution culture with N at 0.75 mM had 1.8 times the dry mass of those provided N at 3.75mM. Form of N in solution did not affect dry mass, but N content of leaves of plants grown with greater than or equal to 50% NH4(+) was 1.3 times as great as that of plants provided only NO3(-). Plants in containers attained maximal dry mass when fertilized with solutions containing N at 10.8 mM from NO3(-), NH4(+), and urea or N at 7.5 mM with equal amounts of NO3(-) and NH4(+). None of the soilless media used consistently evoked growth similar to growth of plants in the soil-based medium.

(200) Janat, M. M., J. L. Stroehlein, et al. (1990). Grape response to phosphorus fertilizer: petiole to blade P ratio as a guide for fertilizer application. Communications in Soil Science and Plant Analysis 21(9/10): 667-686.
A two-year fertilizer study on a mature vineyard of grapes (Vitis vinifera L., cv. 'Cabernet Sauvignon' and 'Sauvignon blanc') was

conducted on a White House sandy loam (fine, mixed, thermic Ustollic Haplargid) soil at the University of Arizona Oracle Agricultural Center. Two cultivars were grown and treated with different levels of N and P fertilizer and tested for total P and NO_3-N content of plant tissues. Available P was evaluated with two extracting methods (Olsen and Bray P_1). Relationships between soil pH, extractable Al, Fe, Mn, and Zn with the availability indexes of soil P were also examined. Furthermore, the effects of P rates and placement on the P content of plant tissue, grape yield, and petiole to blade P ratios were investigated. Three fertilizer placements (0, 25, and 50 cm depths) at rates of 88 g P and 80 g N per vine were used for both cultivars in 1987, whereas, in 1988, three P rates (0, 88, and 176 g P per vine) and 207 g of N per vine were applied. The results of this investigation indicated that fertilizer placement did not have a significant effect on grape yield nor the P content of petioles or leaf blades. Nevertheless, P fertilization of grapes resulted in a significant increase in plant P content and grape yield. Petiole to blade P ratio proved to be a suitable indicator for diagnosis of P status of grape plants.

(201) Schenk, M. K. (1988). N-status of pot plants as evaluated by measurement of substrate and plant sap nitrate. Acta Horticulturae(221): 253-260.

N-status of Begonia-Elatior-Hybr., Cyclamen pers. and Saitpaulia ion. supplied by fertigation could not be determined by substrate analysis. Optimum growth as well as N-deficiency were observed at 10-15 mg Nil substrate. Nitrate content in petiole press sap reflected N-supply of cyclamen and saintpaulias. For begonias, however, nitrate content of petiole sa didn't vary significantly with N-supply because the nitrate concentration was below 200 ppm. This could be related to a high nitrate reductase activity in the root. The nitrate concentration in petiole press sap was hardly influenced by the NO_3:NH_4 ratio of the fertigation.

(202) Smith, D. L. (1988). Plant sap analysis as a monitoring technique for tomatoes in Rockwool. Acta Horticultruae(221): 403-411.

A simplified technique for the extraction and analysis of tomato petiole sap is described. Samples are not frozen before extraction, and the extract is not centrifuged. Sections of petiole are macerated in water, filtered, and analysed as a nutrient solution. The analytical data is used in conjunction with nutrient solution analysis to monitor the nutrient status of commercial glasshouse crops. The requirements and limitations of the technique were investigated in a series of experiments. The time of day of sample collection and the length of time between sample collection and extraction were both shown to affect results, but the additional variation introduced by these factors has proved to be acceptable for routine crop monitoring. It is suggested that the technique as described could form the basis of a general method for monitoring tomatoes and other glasshouse crops in rockwool and similar inert media.

(203) Coltman, R. R. and S. A. Riede (1992). Monitoring the potassium status of greenhouse tomatoes using quick petiole sap tests. HortScience 27(4): 361-364.

'Celebrity' tomatoes (Lycopersicon esculentum Mill.) were grown in peat-perlite under greenhouse conditions in two experiments with five levels of K (25, 50, 100, 200, and 300 mg-liter-1) in irrigation waters. In both experiments, aqueous petiole sap K concentrations (milligrams K per milliliter) were monitored weekly with colorimetric paper test strips. Variation in petiole sap K concentrations among plants was low among three-plant replicates (cvs of 9% to 11%). Petiole sap K concentrations varied considerably from week to week, but remained relatively constant over time at levels determined by external-feed K concentrations. Petiole sap K levels and marketable-fruit yield increased quadratically with increasing external K concentrations. Maximum yields were produced with 190 to 200 mg K/liter in external-feed solutions. Maximum marketable yields of approximately equal to 2.75 kg/plant occurred with approximately equal to 5.9 mg K/ml in petiole sap. Quick petiole sap K tests appear to be suitable for assessing the K status of greenhouse tomatoes.

(204) Timmer, V. R. and G. Armstrong (1987). Diagnosing nutritional status of containerized tree seedlings: comparative plant analyses. Soil Science Society of America Journal 51(4): 1082-1086.

Containerized red pine (Pinus resinosa Ait.) seedlings were fertilized to test the effectiveness of three approaches (critical levels, optimal ratios, and vector analysis) to diagnose seedling nutrient status. Treatments involved a balanced nutrient solution and six imbalanced solutions lacking (-) or enriched (+) with N, P, or K applied to seedlings raised in peat-filled paperpots. Growth was significantly reduced by -N, -P, and +N treatments indicating N and P deficiencies and N toxicity, respectively, and probable sufficiency or luxury consumption of P or K for the other teatments. Diagnosis by vector analysis agreed closely with actual growth and nutritional responses to treatments, and was more precise than the other approaches. Vector analysis was independent of predetermined standards or critical values, and improved identification of dilution effects and nutrient interactions which tend to complicate conventional diagnostic techniques.

(205) Hochmuth, G. J. (1994). Efficiency ranges for nitrate-nitrogen and potassium for vegetable petiole sap quick tests. HortTechnology 4(3): 218-222.

Petiole sap N and K quick tests offer fast and accurate in-field analysis for N and K and have been calibrated for some vegetable crops in Florida. This paper summerizes 10 years of research conducted in Florida on petiole sap testing for N and K. Petiole sap nitrate-N and K concentrations correlated highly with wholeleaf N and K concentrations and decreased through the season for all vegetable crops tested. Optimum early season fresh sap nitrate-N and K concentrations were highest for pepper, and optimum late-season concentrations were lowest for tomato. Petiole sap nitrate-N and K concentrations were not affected by storing petioles on ice for up to 16 h or freezing then for 24 h.

(206) Qian, P., J. J. Schoenau, et al. (1995). Quick extraction and determination of potassium in fresh leaf sap and its use as a guide to potassium fertilization of canola, chickpea, and dwarf sunflower. Communications in Soil Science and Plant Analysis 26(17/18): 2903-2912.

Two simple methods to extract potassium (K) from fresh plant tissues for use as possible quick K tests: i) freeze/squeeze in which the tissue is frozen, thawed and extracted by placement in a syringe, and ii) press in which the sap is extracted by crushing fresh leaves in a garlic press, were evaluated. The K concentration in the leaf sap extracted using the two methods was determined using a hand-held ion selective electrode meter. Two separate growth chamber experiments were conducted to evaluate method performance. In the first experiment, the relationships of fresh leaf sap K with total plant K and with K availability in the soil were determined using canola (Brassica campestris var. Profit) and wheat (Triticium aestivum var. Biggar). In the second experiment, canola (Brassica campestris var. Profit), chickpea (Cicer arientinum), and dwarf sunflower (Helianthus) were grown on two soils low in available K with six rates of added K. The fresh leaf K extracted by the two methods and measured using portable ion selective electrode were well correlated with total plant K concentration at harvest, and also closely reflected the differences in K availability in the soil as indicated by soil extraction and rates

of added K. Among the two methods, the press method using a hand-held squeezing device is the simplest one. However, the freeze/squeeze method may be a more suitable predictor of the K availability in plant tissue that is less succulent.

(207) Westcott, M. P., C. J. Rosen, et al. (1993). Direct measurement of petiole sap nitrate in potato to determine crop nitrogen status. Journal of Plant Nutrition 16(3): 515-521.
Rapid determination of crop nitrogen (N) status in the field would facilitate the use of plant tissue testing as a tool for N management in potato (Solanum tuberosum L.). The Cardy portable nitrate (NO3) meter may provide the means for on-site determination of petiole sap NO3 (PSN) concentration. Our objective was to establish the relationship between Cardy meter readings of PSN and laboratory measures of petiole dry matter NO3 (PDMN). In a two-year replicated field study in western Montana, 'Russet Burbank' potatoes were grown under a line-source sprinkler irrigation system with N fertilization treatments of 0 N or a rate of 270 kg N/ha applied in four different timing schemes. This created a wide range in crop N and water status. Petiole samples were collected at five or six dates each year. Subsamples were analyzed for PSN in expressed sap using the Cardy NO3-specific electrode or for PDMN with a benchtop NO3-specific electrode after extraction with a solution of aluminum sulfate [Al2(SO4)3]. Petiole sap NO3 levels were highly correlated (r = 0.956 in 1990 and 0.971 in 1991) with PDMN. No significant differences in intercept or slope of the regression equations were detected between the two years. The combined regression is: PDMN(%) = 0.00118 X PSN(ppm) - 0.380, r = 0.962 where both variables are expressed on a NO3-N basis. Independent calibration from Minnesota agreed very closely with these results. Criteria for the use of PSN in potato N management can therefore be calculated readily from established PDMN criteria.

(208) Hochmuth, G. J., R. C. Hochmuth, et al. (1993). Eggplant yield in response to potassium fertilization on sandy soil. HortScience 28(10): 1002-1005.
'Classic' eggplant (Solanum melongena L.) responses to K fertilization were evaluated in Spring and Fall 1991 at Live Oak, Fla., on soils testing low in Mehlich-1 extractable K. Total season yield leveled off at 51.1 t-ha-1 with 94 kg K/ha fertilization in spring and at 53.3 t.ha-1 with 60 kg K/ha in fall. Critical K concentrations (in grams per kilogram) in whole leaves were approximately 45 at first flowering, 35 at early fruiting, 30 during harvest, and 28 at the end of seven harvests. Fresh petiole-sap K critical concentrations (in milligrams per liter) were approximately 4500 to 5000 before harvest and 4000 to 4500 during harvest. Less than 3500 mg K/liter in fresh sap indicated K deficiency in fruiting plants. The Mehlich-1 soil extractant procedure predicted similar responses at the two sites; however, yield responses showed that the two sites differed in fertilization requirements. Fertilizer recommendations for K at both sites exceeded eggplant K requirements.

(209) Williams, C. M. J. and N. A. Maier (1990). Determination of the nitrogen status of irrigated potato crops. II. A simple on farm quick test for nitrate-nitrogen in petiole sap. Journal of Plant Nutrition 13(8): 985-993.
*This paper describes the development and calibration of a simple on farm quick test for sap nitrate-N in potatoes (Solanum tuberosum L). A description is given of the plant tissue to sample, bulk sampling procedures, sap extraction, dilution and measurement of sap nitrate-N. Thirty petioles of the youngest fully expanded leaves per plot were collected and bulked. Segments 10-20 mm long were excised from near the centre of each petiole, crushed and the sap collected. One mL of this sap was diluted a hundred-fold. The concentration of nitrate-N sap was determined by immersing a test strip into the 1:100 diluted sap extract and then reading the intensity of colour in the strip by reflectometric analysis with a simple hand held meter. Three strips were read for each sample tested. Standard solutions were used to calibrate test strips. Linear regression equations were used to investigate the relationships between nitrate-N concentration determined in sap and dry matter. A highly significant linear relationship was found between nitrate-N concentration as determined in sap (by the quick test method) and that in dry matter (by a laboratory method), (R^2=0.89***). Effects of site, cultivar, sampling time and certain interactions although significant were of low magnitude and in total accounted for only 7.9% of the total variation in the above relationship. Depending on sampling times, the estimated critical nutrient ranges (CNR) of sap nitrate-N for 95 and 100% of maximum tuber yield varied from 1366.1-1443.7 mg/L, at the first sampling time to 530.0-826.5 mg/L at the final sampling time. These CNR can be used as 'target' levels in crop monitoring programs aimed at efficient N management. The quick test for sap nitrate-N can be used to monitor the N status of crops and recorded nitrate levels compared to our CNR and N applied if needed before significant reductions in yield occur. Each test on collected petioles took only 10 minutes. Costs of equipment and materials for a run of 500 samples (with 3 test strips per sample) were approximately $A2 per sample. This sap test offers a rapid, accurate method for plant tissue nitrate-N analysis that permits the grower or consultant to sample, analyse and monitor potato crops on-farm at a modest cost and could easily be extended to many other crops.*

(210) Hanson, E. J. (1987). Integrating soil tests and tissue analysis to manage the nutrition of highbush blueberries. Journal of Plant Nutrition 10(9/16): 1419-1427.
A total of 539 leaf and soil samples collected from commercial blueberry (Vaccinium corymbosum L.) plantings throughout Michigan between 1975 and 1985 were analyzed for P, K, Ca and Mg. Significant but weak correlations were found between soil and leaf nutrient levels for P (r=0.084), K (0.239), Ca (0.088) and Mg (0.132). Soil levels of K, Ca and Mg were more closely correlated with leaf nutrient levels in young plants (<7 years old) than in older plants, suggesting that soil tests may be most useful in monitoring the nutrient status of young plants.

(211) Carlson, R. M., R. I. Cabrera, et al. (1990). Rapid direct determination of ammonium and nitrate in soil and plant tissue extracts. Communications in Soil Science and Plant Analysis 21(13/16): 1519-1529.
The diffusion-conductivity method (DCM) for NH_4^+ and NO_3^- determinations in soil and plant tissue extracts is tolerant of sample color and turbidity. The instrument can be calibrated for direct analysis of extracts from either low or high level samples. Extracts can be processed at one per minute. Ammonium and NO_3^- can be determined simultaneously at this rate with a two channel prototype instrument. The use of serum filters simplifies sample extract preparation and avoids the NH_4^+ and NO_3^- contamination problem that has been documented for filter papers. The instrument sample intake tube can aspirate extracts directly from the serum filter tube. A variety of soil or plant extracting solutions can be used for both NH_4^+ and NO_3^- determinations. Interference in NO_3^- determinations has been encountered in a few samples where it appears to be due to a high phenolic content.

For these samples, interference is minimized by using two NO_3^- reduction cartrides in series. Comparisons of the DCM procedure with steam distillation-titration for soil extracts and NO_3^- electrode for plant tissues showed excellent agreement. Recovery of standard additions of NH_4^+ and NO_3^- range from 97.4% to 103%

(212) Belden, K. and A. D. Blaylock (1991). Quick facts about your horticultural soil test report. MP University of Wyoming Cooperative Extension Service(67): 3.

(213) Boggero, J. D. and P. Christensen (1976). Comparison of nitrate-nitrogen levels in grape petioles as determined by phenoldisulfonic acid and specific-ion electrode methods. American Journal of Enology and Viticulture 27(2): 51-54.
Inconsistencies have been found in nitrate-nitrogen results obtained by the phenoldisulfonic acid (PDS) and the specific ion electrode methods of analysis with various plant tissues. This study was undertaken to determine if the inherent errors in the phenoldisulfonic acid method produce erratic results in grape petiole tissue analysis. Leaf petiole samples were taken in two 'Thompson Seedless' and one 'Muscat Canelli' vineyard at various stages of vine development during the growing season of 1974. Survey samplings were also made in 25 other 'Thompson Seedless' vineyards at bloom. A comparasion was made of NO_3-N levels as determined by the PDS and the nitrate specific ion electrode procedure. The values obtained by PDS were most often greater than those by the specific ion electrode, particularly at the more critical lower NO_3 levels. The potential errors produced by PDS in this study are not found in the specific ion electrode procedure.

(214) Chweya, J. A. (1988). Contents of nitrate-N and thiocyanate ions in kale (Brassica oleraces var. acephala DC) leaves from kale-growing areas in Kenya. Acta Horticulturae(218): 181-190.
Kale leaves were sampled in November 1984 and March 1985 from the Kisii, Kericho, Nakuru, Nyahururu, Naivasha, Limuru, Karatina and Kibwezi areas and the nitrate-N contents and thiocyanate ions determined. The results indicated significant differences in nitrate-N contents and thiocyanate ions in the leaves from the various areas. Whole leaf nitrate-N contents ranged from 0.03% (Naivasha) to 0.13% DM (Nakuru) for November 1984 samples and from 0.04% (Naivasha) to 0.08% DM (Kisii) for March 1985 samples. Thiocyanate ions ranged from 159 (Nakuru) to 490 (Kericho) and from 502 (Karatina) to 2 804 micrograms KSCN g-1 DM (Limuru) for November 1984 and March 1985 samples, respectively. The results also showed significant diffences between petioles and laminae for both substances. Nitrate-N contents were significantly higher in petioles than in laminae. Lamina nitrate-N values were 19.5 and 13% of those of the petioles in November 1984 and March 1985, respectively. Differences between petioles and lamina thiocyanate ions were significant for the March 1985 samples only. Thiocyanate ions in the petioles were 40% less than those of the laminae.

(215) Coltman, R. R. (1987). Sampling considerations for nitrate quick tests of greenhouse-grown tomatoes. Journal of American Society for Horticultural Science 112(6): 922-927.
Tomato plants were grown in two greenhouse experiments to determine sampling guidelines for using semiquantitative quick tests of petiole sap nitrate to monitor crop N status. In Expt. 1, a 40 microgram NO_3-N/ml liquid feed rate produced maximum marketable yields of 'Celebrity' tomatoes (Lycopersicon esculentum Mill.) (3.4 kg/plant) with estimated petiole sap concentrations of 2138, 1091, and 636 micrograms NO_3-N/ml at early bloom, small fruit and full-ripe fruit stages, respectively. In Expt. 2, a stable minimum level of petiole sap NO_3-N of about 800 microgramsml^{-1} was found during fruit production in maximally yielding (3.1 kg/plant) 'Tropic' tomato plants. These plants received 60 micrograms NO_3- N/ml in liquid feed solutions during fruit production. Liquid NO_3-N feed rate producing maximum yields in these experiments were about five times lower than those typically used for growing tomatoes. Sap nitrate content did not fluctuate greatly between 0803 HR and 1430 HR. Sap nitrate levels rose sharply in response to increased N feed concentrations and as a result of lower leaf pruning. Because of high day-to-day and plant-to-plant variation in petiole sap nitrate reading, strategies for obtaining results with sufficient diagnostic value would appear to involve at least weekly samplings of five to 15 plants, and restricting diagnoses of deficient crop N to instances where readings <800 micrograms NO_3-N/ml for two or more consecutive samplings have been obtained.*

(216) Milham, P. J., A. S. Awad, et al. (1970). Analysis of plants, soils and waters for nitrate by using an ion-selective electrode. Analyst 95: 751-757.
The use of a commercial anion-exchange electrode permits the rapid determination of nitrate in plant material and in non-saline soils and waters. The buffer used eliminates chloride, nitrite and organic anion interferences. The proposed method gives better recovery and reproducibility than the Dervarda method.

(217) Hipp, B. W. (1974). Influence of nitrogen and maturity rate on hollow stem in broccoli. HortScience 9(1): 68-69.
Percent hollow stem in broccoli (Brassica oleracea L. Italica group) was increased as N fertilizer rate increased. Hollow stem incidence was greatest at first harvest but declined with each harvest thereafter. The relationship between days to maturity and percent hollow stems could be described by a parabolic regression equation which indicated that hollow stem percentage was negligible if time to maturity was 110 days or more.

(218) Peng, S., F. V. Garcia, et al. (1993). Adjustment for specific leaf weight improves chlorophyll meter's estimate of rice leaf nitrogen concentration. Agron J 85(5): 987-990.
The chlorophyll meter provides a simple, quick, and nondestructive method to estimate leaf N status of rice (Oryza sativa L.), but the linear relationship between leaf N concentration on a dry-weight basis (Ndw) and the meter reading differs depending on developmental stage and genotype. The objective was to determine whether prediction of Ndw with the chlorophyll meter can be improved by a simple correction for specific leaf weight (SLW). Leaf N status was estimated by a chlorophyll meter (SPAD-502) and measured directly by micro-Kjeldahl procedure. Specific leaf weight was calculated as the ratio of dry weight to leaf area. In one field study with 'IR72', measurements were taken at midtillering, panicle initiation, and flowering stages on the uppermost fully expanded leaves of both N-deficient and N-sufficient plants. There was a linear relationship between Ndw and SPAD values at each stage, but regression lines differed significantly between growth stages. Based on pooled data from all stages, the degree of linear fit was poor ($r(2) = 0.49$). Adjusting SPAD values for SLW (SPAD/SLW) improved the prediction of Ndw ($r(2) = 0.93$). For another set of measurements made on the flag leaves of five genotypes grown in the field and greenhouse, prediction of Ndw was also improved, from $r(2) = 0.51$ based on

SPAD values alone to r(2) = .87 based on the SPAD/SLW ratio. These results demonstrate that SLW influences the prediction of Ndw by the chlorophyll meter, and that the adjustment of SPAD values.

(219) Minotti, P. L., D. E. Halseth, et al. (1994). Field chlorophyll measurements to assess the nitrogen status of potato varieties. HortScience 29(12): 1497-1550.
We report three N rate experiments conducted on a gravelly loam soil to assess the N status of potato (Solanum tuberosum L.) using a Minolta SPAD-502 chlorophyll meter. Highly significant linear and quadratic trends were obtained for the regression of N rate on marketable tuber yields and SPAD readings. SPAD readings were taken at four times during the growing season and decreased as plants aged. Based on regression analysis, the early season SPAD readings, associated with N rates giving maximum marketable tuber yields, ranged from 49 to 56 units depending on year, variety, and location. Potato variety significantly affected SPAD values in eight of the 12 situations where readings were obtained. Precision in interpretation was improved when the highest N rates were considered "reference strips" to standardize the SPAD readings across varieties and growing seasons. Our results suggest that field SPAD readings can readily identify severe N deficiency in potatoes, have the potential to identify situations where supplementary sidedressed N would not be necessary, but would be of limited value for identifying situations of marginal N deficiency unless reference strips are used.

(220) Coltman, R. R. and S. A. Riede (1992). Monitoring the potassium status of greenhouse tomatoes using quick petiole sap tests. HortScience 27(4): 361-364.
'Celebrity' tomatoes (Lycopersicon esculentum Mill.) were grown in peat-perlite under greenhouse conditions in two experiments with five levels of K (25, 50, 100, 200, and 300 mg-liter-1) in irrigation waters. In both experiments, aqueous petiole sap K concentrations (milligrams K per milliliter) were monitored weekly with colorimetric paper test strips. Variation in petiole sap K concentrations among plants was low among three-plant replicates (cvs of 91% to 11%). Petiole sap K concentrations varied considerably from week to week, but remained relatively constant over time at levels determined by external-feed K concentrations. Petiole sap K levels and marketable-fruit yield increased quadratically with increasing external K concentrations. Maximum yields were produced with 190 to 200 mg K/liter in external-feed solutions. Maximum marketable yields of approximately equal to 2.75 kg/plant occurred with approximately equal to 5.9 mg K/ml in petiole sap. Quick petiole sap K tests appear to be suitable for assessing the K status of greenhouse tomatoes.

(221) Widders, I. E. (1989). Pretransplant treatments of N and P influence growth and elemental accumulation in tomato seedlings. Journal of American Society for Horticulture Science 114(3): 416-420.
Tomato (Lycopersicon esculentum Mill.) seedlings, cultured under a moderately low mineral nutrient regime, were fertilized with 4 to 28 mM N and 0.5 to 8 mM P solutions for up to 10 days before transplanting into the field. The high N solution drenches (16 and 28 mM N) promoted accelerated seedling growth, higher relative growth rates during the initial 5 days after field setting, and an increased net accumulation of N and P in the shoot following transplanting into the field. Pretransplant treatments with P did not result in a shoot growth response. The total P concentrations and contents in shoot tissues, however, were significantly higher in the seedlings treated with 4 or 8 mM P than in those receiving 0.5 mM P. Since the rates of P uptake and accumulation in the shoot relative to shoot biomass were enhanced by both the N and P pretransplant treatments, root initiation and growth may have been stimulated.

(222) Hicklenton, P. R. and K. B. McRae (1989). Mineral status and growth of containerized Compact Andorra juniper under different irrigation and fertilizer regimens. Canadian Journal of Plant Science 69(4): 1295-1300.
Juniperus horizontalis 'Plumosa Compacta' were grown in 3.8-L containers to compare the factorial effects of irrigation (top vs. capillary) and controlled release fertilizer placement (incorporated vs. surface-applied) on shoot nutrient content and growth. These treatments were compared with a liquid fertilized control. Shoot N contents on 30 June (31 d after potting) were highest in plants which were top-irrigated and supplied with incorporated Nutricote, but were lowest in these plants at the end of the season (28 Sept.). Top-irrigated, Nutricote-incorporated, and liquid-fertilized plants showed the highest shoot K contents on 30 June. Lowest shoot K occurred in the top-irrigated, Nutricote-incorporated treatment on 28 Sept. In comparison with N or K, shoot P showed much less variation over the growing season. Incremental branch growth was less when fertilizer was surface applied than when it was incorporated, but end-of-season shoot dry weights were similar in all plants except those which were top irrigated and supplied with incorporated Nutricote. This treatment produced the highest end-of-season shoot dry weight and best overall growth. Seasonal growth was positively correlated with early season (30 June) shoot N and K contents.

(223) Simpson, D. G., C. F. Thompson, et al. (1993). Field performance potential of interior spruce seedlings: effects of stress treatments and prediction by root growth potential and needle conductance. Canadian Journal of Forestry Research 24(3): 576-586.
Root growth potential (RGP) and needle conductance to water vapour (Gn) of container-grown interior spruce (Picea glauca - (Moench) Voss Picea engelmannii Parry complex) seedlings that had been subjected to mechanical (dropping), low-temperature (-15 degrees C), or heat (35 degrees C) stresses were determined prior to planting on two forest sites. Field performance measured as survival, height, stem diameter, stem volume, and mean stem volume relative growth rate (RGR) was assessed for each of the 4 years following planting. RGP, Gn, and field performance did not differ between mechanically stressed and nonstressed seedlings. Low temperature and heat stresses reduced RGP, Gn, and field performance of some batches of seedlings, indicating that stock lots with different nursery cultural history had substantially different stress resistance. RGP and Gn were correlated with field performance such that for RGP greater than five new roots per seedling, high (>80%) survival and to a lesser extent greater growth occurred, whereas for RGP less than five new roots per seedling, survival and growth were unpredictable. High survival and better growth occurred for stock lots having Gn >50 mmol.m-2.s-1, while for Gn <50 mmol.m-2.s-1, survival decreased. Preplanting stress effects on growth were small and due to RGR reductions in the first field season, which are projected to result in a time delay of 1 year or less in trees reaching a height of 150 cm and a stem diameter of 3.5 cm.

(224) Devitt, D. A., M. Berkowitz, et al. (1993). Estimating transpiration for three woody ornamental tree species using stem-flow gauges and lysimetry. HortScience 28(4): 320-322.
We compared transpiration estimates of three common desert landscape tree species using stem-flow gauges and lysimetry. Argentine mesquite (Prosopis alba Griseb.ach), desert willow [Chilopsis linearis (cav.) Sweet var. linearis], and southern live oak (Quercus virginiana Mill., seedling selection) were subjected to three irrigation regimes. Leaching fractions of +0.25, 0.00, and -0.25 were imposed for 2 years. During the summer of the second

year, we conducted a comparative transpiration study. Trees growing in 190-liter plastic containers had a highly linear correlation ($r = 0.98$, $p = 0.001$) between transpiration estimated by stem-flow gauges and lysimetry. An average 18% error was measured between paired data (total runs of 14 to 72.5 hours) of stem-flow gauge and lysimetry transpiration estimates. However, a lower error was correlated significantly with longer run times ($r = -0.37$, $P = 0.05$). Based on field measurements taken in this experiment, run times would have to be >68 hours to maintain an associated error below 10%. Higher cumulative transpiration also was associated with longer run times ($r = 0.80$, $P = 0.001$). These results suggest that the stem-flow gauge can be used to estimate transpiration accurately to schedule irrigation for woody ornamental trees in an arid environment, provided that irrigation predictions are not based on short-term stem-flow gauge estimates (<68 hours).

(225) Rangeley, A. (1989). The suitability of plant tissue tests to indicate phosphorus deficiency in perennial ryegrass (Lolium perenne L.). Grass and Forage Science Journal 44(1): 91-95.
The phosphorous (P) status of perennial ryegrass was measured using three tissue tests. The results were compared with dry matter (DM) production from ryegrass, and levels of extractable soil P, taken from a fertilized non-calcareous gley in a field experiment. Large errors were associated with the test values but it was possible to separate P deficiency from luxury uptake with tissue tests for total P and inorganic P (Pi) in leaves. The latter test is simple and merits further investigation.

(226) Burns, I. G. and W. Hutsby (1986). Choice of leaf for estimation of K status by analysis of petiole sap. Journal of the Science of Food and Agriculture 37(2): 115-128.
Glasshouse experiments were carried out to examine the way in which potassium was redistributed within lettuce plants during development and alleviation of K deficiency, with a view to providing a more objective method of selecting the best leaf for sap analysis. The changes in distribution of K between leaves were measured by analysis of samples of petiole sap and were compared with the corresponding changes in overall K status of the plants determined by analysis of the total shoot dry matter. Young expanding leaves were most sensitive to alterations in external K supply: their sap concentrations changed more quickly than in any of the older leaves, but because of the inherently lower concentrations in these immature leaves, the overall size of these changes was ultimately less than in fully developed ones. Satistical analyses also showed that measurements of K in the sap from young expanding leaves were more precise than from mature ones. Relative changes in K concentration in the sap of these expanding leaves also occurred initially more quickly than in the total shoot dry matter, but measurements on the latter were considerably more precise. It was concluded that for sap K analysis the best results were obtained using an immature leaf.

(227) Argo, W. R., B. J. Weesies, et al. (1997). Evaluating rhizon soil solution samplers as a method for extracting nutrient solution and analyzing media for container-grown crops. HortTechnology 7(4): 404-408.
The rhizon soil solution sampler (RSSS) currently is being used for in situ extraction of the soil solution for nutrient analysis of mineral soils used to produce field-grown crops. In this study, laboratory and greenhouse experiments were conducted to test the effectiveness of the RSSS for in situ solution extraction from soilless container root media and to compare an RSSS extraction method for measuring root-medium pH, electrical conductivity (EC), and NO_3-N and K concentrations with that measured with the saturated media extract (SME) method. A near 1:1 correlation was found between the pH, EC, and NO_3-N and K concentrations measured in the extracted solution of the RSSS and SME method in media without plants and in media from ten species grown using three water-soluble fertilizer concentrations applied by subirrigation. More testing is needed with the RSSS, perhaps using composite samples from several pots for analysis. The RSSS shows promise for nutrient extraction in container-grown crops because it is fast, nondestructive, simple, economical, and has minimal effect on the nutritional status of the medium in the pot.

(228) Matkin, O. A. (1970). Use of soil analysis in osmocote fertilizer programs. HortScience 5(3): 180-181.
A method of determining the reserve fertilizer content of soil containing encapsulated slow-release fertilizer was tested. The procedure involved dual analysis by extraction before and after rupturing fertilizer capsules using a cereal grinder. Dry soil bulk density measurement permited calculation of theoretical fertilizer concentration. Comparison of calculated versus concentrations found were very close for potassium and nitrogen. Phosphorus found by analysis was lower than theoretical.

(229) Jemison, J. M., Jr. and R. H. Fox (1988). A quick-test procedure for soil and plant tissue nitrates using test strips and a hand-held reflectomter. Communications in Soil Science and Plant Analysis 19(14): 1569-1582.
Development of a nitrate quick-test for use by farmers or field consultants would likely encourage the use of plant tissue and soil nitrate tests as a means to improve nitrogen management. To evaluate a quick-test method, nitrate concentrations in plant tissue and soils were measured using commercially available nitrate test strips and a hand-held reflectometer. The results were compared with those obtained with standard laboratory methods. Test strip accuracy and precision and reflectometer precision were determined over a 10 day period using standard KNO_3 solutions and colored paper strips. Coefficients of variation ranged from 22.3 to 9.5 percent for the test strips and from 3.5 to 1.6 percent for the reflectometer. Quick-test results were highly correlated with laboratory results for both plant tissue nitrate (r=0.87) and soil nitrate (r=0/98) concentrations. Results indicated that test strips provide a rapid, reasonably accurate and precise method to determine nitrate concentrations in both soil and plant material.

(230) Raun, W. R., H. J. Barreto, et al. (1989). Frozen versus non-frozen sample preparation for plant tissue phosphorus analysis. Communications in Soil Science and Plant Analysis 20(1/2): 197-211.
Maize (Zea mays L.) and wheat (Triticum aestivum L.) plant tissue was collected from phosphorus fertility experiments at two locations in 1985. Two samples were collected from each experimental unit and randomly either frozen immediately following collection or stored and dried normally prior to being analyzed for total P (HNO_3-$HCLO_4$ acid digest) and inorganic P (CH_3COOH extract). Corn was sampled at the eight and twelve leaf stages and wheat at Feekes stage five. Freezing was accomplished using liquid N (wheat-Feekes stage five) and dry ice (corn-eight and twelve leaf stages). Inorganic P was found to be greater when frozen at the twelve leaf stage versus the conventional non freezing procedure. Alternatively, the opposite was found for wheat at Feekes stage five. The freezing procedure was found to increase the total P concentration for both corn at the twelve leaf stage and wheat at Feekes stage five. Losses of CO2 were expected in the conventional non-frozen samples due to an induced leaf respiration (eight hours from the time samples were collected to the time they entered the drying oven) which should have reduced dry weight and subsequently increased

concentration. Because this was not found and since all other procedures employed were identical other than freezing, it is expected that P volatilization losses must have occured in the non-frozen samples for corn at the twelve leaf stage and wheat at Feekes stage five.

(231) Yelanich, M. V. and J. A. Biernbaum (1993). Root-medium nutrient concentration and growth of poinsettia at three fertilizer concentrations and four leaching fractions. Journal of the American Society for Horticulture Science 118(6): 771-776.
'V-14 Glory' poinsettias (Euphorbia pulcherrima Willd. ex Klotzsch) were fertilized at every irrigation with solutions containing 7, 14, or 28 mol N/m3 at four leaching fractions (LFs) of 0, 0.1 to 0.2, 0.3 to 0.4, or 0.5 to 0.6 or with subirrigation. The N applied ranged from 44 to 464 mmol/pot applied over 12 to 25 irrigations. Medium NO3-N and K concentrations and electrical conductivity were highest at the highest fertilizer concentration and lowest LF throughout cropping. Phosphorous concentration in the medium declined until week 12, when phosphoric acid was added for pH adjustment. Subsequently, medium P concentration was highest in treatments with the highest LF. Final shoot height, plant dry mass, and leaf area decreased as fertilizer concentration increased. Highest fresh mass, bract area, and shoot:root ratio were obtained with 14 or 28 mol N/m3 and a 0.55 LF or with 7 mol N/m-3 and a 0.15 LF. Leaf N concentration was lower with subirrigation than with surface application. Leaf P and Mg were lower at higher LFs or with subirrigation, but leaf K was not influenced by the treatments.

(232) Subramanian, C. K. (1973). A quick method for correlation of soil test values with plant response. International Symposium on Soil Fertility Evaluation 1: 371-375.
An experiment was carried out for interpretation of soil test for phosphorus using soils from 15 locations in Mysore State with wheat as test crop, grown for 17 days on 100 g each of the soil under test in small circular bakelite containers. Three phosphorus treatments were used viz., (1) no P, (2) adequate P and (3) twice adequate P. Adequate P was determined separately for each soil (Waugh & Fitts 1966). The technique of Cate and Nelson (1965) was used for the correlation of soil test values with plant response. Available P was measured using 4 extractants commonly used in soil testing laboratories and the data were plotted against percentage yield of dry matter to select (1) a most acceptable extractant and (2) to estimate the value of the critical level below which the probability of an economic reponse to phosphorus fertilizer is high. Data indicated that Bray extractant is suitable for acid soils of Malnd tract of Mysore and the critical soil test value is 2.5 ppm under the condition of the experiment.

(233) Milham, P. J. (1970). Potentiometric nitrate analysis: a flow-through electrode unit. [Plant physiology]. Analyst 95: 758-759.

(234) Burton, K. W., J. B. King, et al. (1986). Chlorophyll as an indicator of the upper critical tissue concentration of cadmium in plants. Water, Air, and Soil Pollution 27(1/2): 147-154.
The upper critical concentration for Cd in wheat plants (Triticum aestivum) grown in Hoagland's solution, was found by the method of Beckett and Davis (1977) to be 44 micrograms $^{-1}$ dry weight, using shoot chlorophyll levels as an indicator of plant health. Chlorophyll compared favorably with other indices of growth and may, in conditions where metal toxicity is manifest as chlorosis, be more accurate and sensitive than shoot dry weight or longest root lengths. It was not possible with the limited number of experiments conducted here to determine, with any degree of confidence, differences in the levels at which chlorophylls a and b were affected.

(235) Sydnor, T. D., R. K. Kimmins, et al. (1972). The effects of light intensity and growth regulators on gloxinia. [Sinningia speciosa]. HortScience 7(4): 407-408.
Low light intensity caused an increase in size and a delay in flowering of gloxinia (Sinningia speciosa Benth and Hooke cv. Dwarf Delight and Royal Frosted Red). The growth regulators succinic acid-2,2-dimethyl hydrazine (SADH) and alpha-cyclopropyl-alpha-(4 methoxyphenyl)-5-prymidinemethanl (ancymidol) decreased plant size and delayed flowering. 'Dwarf Delight' showed damage in response to ancymidol at 250 mg/l and higher but 'Royal Frosted Red' showed no damage. SADH caused a noticable increase in anthocyanin content of the inflorescence and chlorophyll content of the leaves.

(236) Voogt, W. (1988). The growth of beefsteak tomato as affected by K/Ca ratios in the nutrient solution. Acta Horticulturae(222): 155-165.
In an experiment with beefsteak tomato grown in NFT the uptake of nutrients was studied. Four K/Ca ratios were compared. The results showed that a mole ratio of K:Ca = 78:22 in the nutrient solution supplied seemed to be optimal. This resulted in a mole ratio of K:Ca = 63:37 in the recirculating nutrient solution. The course of the K and Ca uptake was affected by the fruit load of the crop. The results showed that the ratio between uptake of nutrients and water was closely related with radiation and plant age. Element contents in tissues of older plants were lower than in comparable tissues of younger plants. These facts lead to the supposition that with increading plant age, plants become less effective in the absorption of nutrients. Production was adversely affected by low K as well as by low Ca. Fruit quality improved with increasing K supply. The analytical data of tissue analysis showed a close relationship between the contents of K and Ca in laminae, petioles and fruits and the quantites of these elements supplied. However, with increasing concentrations of K, saturation effects appeared, while for Ca the contents in the tissue consistently increased with increasing supply.

(237) Sibley, J. L., D. J. Eakes, et al. (1996). Foliar SPAD-502 meter values, nitrogen levels, and extractable chlorophyll for red maple selections. HortScience 31(3): 468-470.
Twelve red maple selections in an existing field trial were evaluated for leaf chlorophyll content with a SPAD-502 chlorophyll meter, total foliar N concentration with a LECO CHN analyzer, and total foliar chlorophyll content (CHL) by N,N-dimethylformamide extraction. Selections included Acer rubrum L. 'Autumn Flame', 'Fairview Flame', 'Franksred' (Red Sunset), 'Karpick', 'Northwood', 'October Glory', 'Redskin', 'Schlesingeri', and 'Tilford', and A. xfreemanii E. Murray 'Autumn Blaze' ('Jeffersred'), 'Morgan' ('Indian Summer'), and 'Scarsen' (Scarlet Sentinel). 'Franksred' and 'Northwood' had the highest monthly SPAD-502 values in 1993 and 1994. Lowest SPAD-502 values were on 'Redskin' and 'Autumn Blaze' each year. Foliar N concentration ranged from 2.62% for 'Autumn Flame' to 2.01% for Redskin. CHL levels on a fresh-weight basis ranged from 5.38 mg.g-1 for 'Fairview Flame' to 3.94 mg.g-1 for 'October Glory'. SPAD-502 and extractable CHL values were correlated (r = 0.45; P less than or equal to 0.001); however, the correlation (r = 0.15; P less than or equal to 0.38) between SPAD-502 values and total foliar N concentration was nonsignificant.

(238) Merrick, J. E. (1975). Oxadiazon-weed control in ornamentals. Proceedings of the Northeastern Weed Science Society 29: 341-344.
A granular formulation of 2-tert-butyl-4(2,4-dichloro-5-iso-propoxyphenyl-4 ^{2} -1,3,4-oxadiazon-5-one (oxadiazon resulted in excellent annual broadleaf and grass weed control when applied

preemergence at 2.0 and 4.0 lbai/A. No difference in weed control was noted with oxadiazon applications to either bare soil or mulched container plants.

(239) Barnes, J. R. (1975). Napropamide for control of weeds in ornamentals and commercial nurseries. Proceedings of the 46th annual Meeting of the Northeastern Weed Science Society 29: 340.
2-(a-naphthoxy)-N,N-diethylpropionamide (napropamide) has been evaluated on numerous ornamental cultivars over the past 3-4 years. Data summarizing plant tolerance and weeds controlled for napropamide alone or in combination with 2-chloro-4,6-bis(ethylamino)-s-triazine (simazine) are reviewed. Flexible use patterns and various timings of application give effective seasonal weed control. Use rates for napropamide vary from 4-6 lb/A for fall applications to 3-6 lb/A for spring applications. Simazine at 3/4-1 lb/A is added to improve overall broadleaf weed control on triazine tolerant species.

(240) Young, R. S. and W. V. Welker (1981). Oryzalin Alone and in Combination for Culture of Fruit Trees. Northeastern Weed Science Society 35: 138-142.
Diuron[3-(3 4-dichlophenyl)-1,1-dimethylurea], oryzalin (3,5-dinitro-N4,N4-dipropylsulfanilamide) and simazine[2-chloro-4,6 bis(ethylamino)-s-triazine] were applied in 1979 and 1980 alone and in combination with varying rates of oryzalin to young peach (Prunus persica L. Batsch) trees at two widely sparated locations, (Cream Ridge, NJ and Kearneysville WV.) and in 1980 to young apple (Malus domestica Borkh.) trees at Kearneysville WV. Weed control was increased when combinations of the herbicides were applied as compared to the individual herbicide used alone. Tree vigor and fruiting was influenced by treatments.

(241) Ahrens, J. F. (1981). Chemical Control of Established Weeds in Field-grown Arborvitae. Northeastern Weed Science Society 35: 248-252.
Sprays of asulam and glyphosate alone or in combination with simazine and oryzalin or surfactant were applied in early April to control established winter annual weeds in dormant arborvitae. Repeated applications were made in June and July. Simazine at 2 lb/A alone was more effective in controlling winter annual weeds than simazine 1lb/A + oryzalin 3 lb/A, but control in June and July was better with the latter. Asulam at 1.67 or 3.34 lb/A plus simazine-oryzalin and glyphosate at 0.375 lb/A or 0.75 lb/A plus simazine-orysalin gave better control of winter annual weeds than simazine-oryzalin alone without injury to dormant arborvitae. Repeating the applications of asulam did not injure actively growing arborvitae, but repeating the applications of glyphosate at 0.75 lb/A or 0.375 lb/A plus surfactant injured the arborvitae.

(242) Porter, W. C. (1996). Isoxaben and isoxaben combinations for weed control in container-grown herbaceous flowering perennials. Journal of Environmental Horticulture 14(1): 27-30.
Gallery DF (isoxaben), Snapshot DF (isoxaben+oryzalin), and Snapshot TG(isoxaben=trifluralin) were applied to four species in 1991 and to nine species in 1992 of container-grown herbaceous flowering perennials to evaluate efficacy, phytotoxicity, and effect on plant growth. Surflan AS (oryzalin) and Treflan 5G (trifluralin) were used as standard herbicide checks. Gallery was applied at 0.56, 0.84, and 1.12 kg ai/ha (0.5, 0.75, and 1.0 lb ai/A). Snapshot DF and Snapshot TG were applied at 2.8, 4.2, and 5.6 kg ai/A (2.5, 3.75, and 5.0 lb ai/A). Coreopsis was not aggected by any herbicide treatment either year. Painted daisy was injured by all treatments except Snapshot TG at 2.5 lb ai/A and Trflan. Gallery at 1.12kg ai/ha (1.0 lb ai/A) and Snapshot DF at 5.6 kg ai/ha (5.0 lb ai/A), injured all species except coreopsis and hibiscus. Surflan injured gloriosa daisy (1991 only), chrysanthemum, hollyhock, hibiscus, and painted daisy. Snapshot TG applied at 5.6 kg ai/A (5.0 lb ai/A) injured hollyhock. Height of coreopsis, shasta daisy, gloriosa daisy, and columbine was not affected or only slightly reduced by any treatment. Hollyhock, hibiscus, painted daisy, and chrysanthemum were generally shorter in containers treated with Snapshot DF at 4.2 kg/ha or higher rates.

(243) Fretz, T. A. (1977). A comparison of oryzalin and profluralin for weed [Digitaria sanguinalis, Amaranthus retroflexus] control in container grown nursery stock. Ohio Agricultural Research and Development Center. 226: 39-41.

(244) Fretz, T. A. and W. J. Sheppard (1979). Evaluation of Oxadiazon for Weed Control in Container-Grown Nursery Stock. Ohio Agricultural Research and Development Centre(246): 33-35.
Pre-emergent applications of oxadiazon (Ronstar) at 2.0, 4.0, 8.0 and 16.0 lb ai/A in three granular formulations (2.5, and 10G) were made to five species of container-grown nursery stock. The 4.0 lb ai/A rate of oxadiazon in the 2G formulation resulted in effective grass and broadleaf weed control with no phytotoxicity.

(245) Neal, J. C. and A. F. Senesac (1990). Preemergent weed control in container and field grown woody nursery crops with gallery. Journal of Environmental Horticulture 8(3): 103-107.
Two container and four field tests were conducted to evaluate Gallery (isoxaben) for preemergent weed control in container and field grown woody nursery crops. Gallery was applied to newly potted nursery ceops at 0.56 and 1.1 kg ai/ha (0.5 and 1 lb-ai/A) alone and in combination with Surflan (oryzalin) or Treflan (trifluralin). No injury was observed on container grown azalea 'Coral Bells', Rhododendron 'Roseum Elegans', rockspray cotoneaster, forsythia, potentilla 'Tangerine', Japanese dwarf garden juniper, 'Old Gold' juniper, or plaintain lily 'Albo-marginata'. Gallery, applied alone, caused no injury to field grown sawara false cypress, honey locust, Japanese yew, California privet, 'San Jose' holly, white pine, Douglas fir, white fir, green ash, or Japanese rose. Gallery injured field grown common lilac. When combined with Surflan, temporary reduction in white fir and Japanese barberry quality resulted. Douglas fir was injured significantly by Surflan, alone or in combination with Gallery. Gallery provided excellent control of many broadleaf weeds including pigweed, common groundsel and dandelion, but poor control of annual grasses such as crabgrass, goosegrass, and fall panicum. The combination of Gallery plus Surflan provided an expanded spectrum of weed control with excellent safety on most container and field grown woody nursery crops.

(246) Creager, R. A. (1981). A comparison of oxadiazon and oryzalin in container-grown nursery stock Herbicides. South Nurserymen's Association Nursery Research Journal 7(2): 15-28.
Two formulations of oxydaizon (Ronstar) were compared to two formulations of oryzalin (Surflan) for efficacy, phytotoxicity, and final plant size effects on container-grown nursery stock. Oxadiazon (2 and 5% granular formulations) were compared to oryzalin (75% wettable powder) on 6 species in 1977 and to oryzalin (41.3% aqueaous solution) on 7 species in 1978. Oxadiazon at 4.48 kg/ha (4 lb/A) provided 75% or better weed control throughout a 4 month period without limiting plant growth or causing significant injury to cultivars of Cotoneaster, Ligustrum, and Pyracantha grown in 3.8 L (1 gal.) containers. The same herbicide treatment was effective for 2 months in cultivars of Ilex, Euonymus, Juniperus and Rhododendron. No formulation of oryzalin provided full season weed control on any species at the manufacturer's suggested rate. Plant size was proportional to the degree of weed control obtained.

(247) Whitcomb, C. E. and C. Boyer (1979). Activity of Ronstar (Oxadiazon) in Containers as Affected by the Growing Media.

South Nurserymen's Association Nursery Research Journal 6(2): 14-18.
Ronstar was applied to eleven container growing media and evaluated for herbicide activity after 3, 6, and 9 weeks. Ronstar activity decreased as the proportion of ground pine bark in the growing medium increased. These data suggest that the safe rate of Ronstar and weed control obtained are dependent on the growing medium composition.

(248) Challa, P. (1988). Effect of pre-emergent herbicides on nutrient status of mango leaves. Acta Horticulturae(231): 321-324.
Leaf analytical studies of mango seedlings from nursery plots treated with pre-emergent sprays of atrazine, diuron, fluchloralin and oxyflourfen revealed that these herbicides affect the uptake of certain minerals without affecting visual crop growth. Significant increase in nitrogen and potassium contents of leaves in the treated plants were noticed. Calcium content of leaf was found to have reduced significantly with phosphorus and iron remaining almost at par with control except at higher herbicide concentration where a decreasing trend was observed.

(249) Wadsworth, G. L. (1975). Evaluation of eight herbicides in container nursery stock [of ornamental plants]. Proceedings of the International Plant Propagation Society 25: 471-475.
Eight herbicides were evaluated for their effectiveness in reducing weed growth in 32 plant cultivars of containerized nursery stock. Oxadiazon at 4 and 8 lb ai/A (active ingredients per acre) gave excellent weed control with only slight phytotoxicity. Oryzalin a 4 and 8 lb gave excellent weed control but exhibited severe phytotoxicity. The combination of alachlor at 8 lb. and simazine at 2 lb. gave good weed control and were only slightly phytotoxic. Alachlor at 8 lb. gave fair to good weed control and was slightly phytotoxic. Profluralin at 4 and 8 lb. gave fair weed control and damaged the nursery stock the least of any of the herbicides tested. Napropamide at 4 and 8 lb. gave fair weed control and was slightly phytotoxic. Simazine at 1 and 2 lb. gave fair weed control and was slightly phytotoxic. Trifluralin at 4 and 8 lb. gave the poorest weed control of all the materials evaluated, but since most of the weed population were broadleaf weeds this result was not surprising. Trifluralin was only slightly phytotoxic. Pronamide at 2 and at 4 lb. gave poor control of weeds and was the second most phytotoxic.

(250) Fretz, T. A. (1972). Performance of herbicides on container-grown nursery stock. University of Georgia, College of Agriculture Experiment Stations, Research Report(120): 1-11.

(251) Fretz, T. A. and W. J. Sheppard (1980). Prodiamine: a promising herbicide for weed control in container nursery production. HortScience 15(4): 489-490.
Pre-emergent applications of prodiamine-2% G [2,4-dinitro-N3,N3-dipropyl-6-(trifluoromethly)-1,3-benzene-diamine] at 1.7, 3.4, 6.7, and 13.4 kg ai/ha effectively controlled large crabgrass (Digitaria sanguinalis (L.) Scop.), redroot pigweed (Amaranthus retroflexus L.), and common lambsquarter (Chenopodium album L.) for up to 113 days after application. No injury was noted on any of the test species following application of prodiamine when compared to the control plots.

(252) Fretz, T. A. (1972). Control of annual weeds in container grown nursery stock. Journal of the American Society of Horticulture Science 97(5): 667-669.
Seven herbicides were evaluated for their safety and efficacy on 5 species of container grown nursery stock. During both growing seasons all materials except chlorpropham at 2.2 and 8.9 kg/ha, chlorpropham at 2.2 and 8.9 kg/ha + PPG-124 at 0.4 and 1.7 kg/ha, resp., and diphanamid at 5.6 kg/ha gave satisfactory long season (163 days) broadleaf weed control. Long season grass weed control in nursery containers was achieved both years with dichlobenil at 13.4 kg/ha, trifluralin at 2.2 and 8.9 kg/ha, EPTC at 5.6 and 22.4 kg/ha, chlorpropham + PPG-124 at 8.9 + 1.7 kg/ha and diphenamid at 22.4 kg/ha. Both azalea species employed in the test exhibited severe chlorosis, necrosis, and stunting when dichlobenil at 13.4 kg/ha and EPTC at 22.4 kg/ha were employed. Japanese holly and 'Sasanqua' camellias were severely injured by dichlobenil at 13.4 kg/ha, while 'Hetzi' juniper was tolerant to all herbicides at all rates employed.

(253) Hubbard, J., T. Whitwell, et al. (1992). Influence of herbicides on shipping quality of landscape plants. Journal of Environmental Horticulture 10(1): 17-18.
Japanese barberry 'Crimson Pygmy', Crape myrtle 'Byers Hardy Lavender' and azalea 'Girard Scarlet' were treated with either Southern weedgrass control (pendimethalin) at 3.4 kg ai/ha (3.3 ai lb/A) or Ornamental Herbicide-2 (oxyfluorfen + pendimethalin) at 3.4 kg ai/ha (3.3 lb ai/A) or 6.7 kg ai/ha (6.6 lb ai/A) prior to simulated shipping in an enclosed environment. No injury was observed on any plants as a result of herbicide treatments.

(254) Hahn, R. R. (1993). New prowl formulation has advantages. Cooperative Extension Association of Allegany County(March): 8-9.

(255) Lovelidge, B. (1980). The Ideal Autumn Herbicide? Arable Farming 7(7): 73, 75, 77.

(256) Derr, J. F. (1993). Wildflower tolerance to metolachlor and metolachlor combined with other broadleaf herbicides. HortScience 28(10): 1023-1026.
The tolerance of transplanted lanceleaj coreopsis (Coreopsis lanceolata L.), ox-eye daisy (Chrysanthemum leucantheum L.), purple coneflower [Echinaea purpurea (L.) Moench.], and blanket flower (Gaiuardia aristata Pursh) to metolachlor was determined in field trials. Metolachlor at 4.5 kg.ha-1 (maximum use rate) and 9.0 kg.ha-1 (twice the maximum use rate) did not reduce stand or flowering of any wildflower species after one or two applications, although plants developed transient visible injury. Combining metolachlor with the broadleaf herbicides simazine or isoxaben resulted in unacceptable injury and stand reduction, especially in ox-eye daisy. Metolachlor plus oxadiazon was less injurious to the wildflowers than metolachlor plus either simazine or isoxaben. Treatments containing metolachlor controlled yellow nutsedge (Cyperus escukntus L.) by at least 89% in both experiments. Treatments containing isoxaben controlled eclipta (Ecupta alba L.) 100% in both studies.

(257) Colbert, F. O. and D. H. Ford (1987). Isoxaben for broadleaf weed control in ornamentals, turf and nonbearing trees and vines. Proceedings of Western Society of Weed Science 40: 155-163.

(268) Bing, A. (1975). Nursery weed control experiments. Proceedings of the Northeastern Weed Science Society 29: 345-348.
Combinations of 1 lb ai/A simazine with 4 lb ai/A alachlor, or 0.5 lb ai/A metribuzin or 4 lb ai/A napropamide are effective preemergence herbicides and safe on a variety of cultivars of nursery stock.

(269) Ryan, G. F. (1976). Herbicides for container grown nursery stock [Poa annua, Cardamine oligosperma, Cerastium vulgatum, Senecio vulgaris]. Weed Science 24(3): 261-265.
Over a 3-yr. period 10 herbicides were tested alone or in combination for control of weeds and for effects on growth of

nursery stock in containers. Annual bluegrass (Poa annua L.) was controlled by norea, alachlor, and combinations of diphenamid, trifluralin, and nitralin plus simazine. Bittercress (Cardamine oligosperma Nutt.) was controlled by simazine, oxadiazon, and norflurazon. Mouseear chickweed (Cerastium vulgatum L.) was controlled by dichlobenil and norflurazon, and common groundsel (Senecio vulgaris L.) was controlled by dichlobenil and norflurazon. Some of the treatments decreased growth of certain nursery cultivars.

(270) Jaramillo, A. E. and P. W. Owston (1977). Two acids equal for growth and mineral content of container-grown [conifer] seedlings [Hydrogen-ion concentration of potting mixtures]. Tree Planter's Notes 28(1): 16-17.

(271) Smith, E. M. and S. A. Treaster (1991). A two-year study of the effectiveness of gallery and snapshot herbicides in container and field nurseries. Special Circulation Ohio Agriculture and Research Development Centre. Ornamental Plants a Summary of Research(137): 6-9.
The pre-emergence herbicides Gallery (isoxaben), Snapshot DF (isoxaben and oryzalin), and Snapshot G (isoxaben and trifluralin) were evaluated for efficacy and phytotoxicity of woody landscape plants produced in the and in containers. The most effective product in both the containers and field was Snapshot DF at 3.0 and 4.0 lbs. aia. It was also the most injurious of the three herbicides, particularly on rooted cuttings of spirea and much less on one-year old plants.

(272) Whitcomb, C. E. and J. F. Butler (1975). Performance of trifluralin, nitralin, and oryzalin [herbicides] in nursery containers [Ilex cornuta]. Journal of the American Society for Horticulture Science 100(3): 225-229.
Trifluralin applied as a spray to a growing medium in nursery containers remained near the surface over a 42 day period at all rates. Oryzalin moved readily through the containers at all rates and after only a small amount of leaching. Nitralin was intermediate in movement. Top and root growth measurements of Ilex cornuta (Lindl) 'Burford' treated with the 3 herbicides showed that as herbicide movement increased, fresh weights of tops and roots decreased. When herbicides were applied a second time during the growing season, damage from nitralin and oryzalin increased. Trifluralin did not damage established holly plants at the 4.5 or 8.9 kg rate after 1 or 2 applications.

(273) Derr, J. F. (1993). Wildflower tolerance to metolachlor and metolachlor combined with other broadleaf herbicides. HortScience 28(10): 1023-1026.
The tolerance of transplanted lanceleaf coreopsis (Coreopsis lanceolata L.), ox-eye daisy (Chrysanthemum leucantheum L.), purple coneflower [Echinaea purpurea (L.) Moench.], and blanket flower (Gaiuardia aristata Pursh) to metolachlor was determined in field trials. Metolachlor at 4.5 kg.ha-1 (maximum use rate) and 9.0 kg.ha-1 (twice the maximum use rate) did not reduce stand or flowering of any wildflower species after one or two applications, although plants developed transient visible injury. Combining metolachlor with the broadleaf herbicides simazine or isoxaben resulted in unacceptable injury and stand reduction, especially in ox-eye daisy. Metolachlor plus oxadiazon was less injurious to the wildflowers than metolachlor plus either simazine or isoxaben. Treatments containing metolachlor controlled yellow nutsedge (Cyperus esculntus L.) by at least 89% in both experiments. Treatments containing isoxaben controlled eclipta (Ecupta alba L.) 100% in both studies.

(274) Whitcomb, C. E. and C. Boyer (1981). Growing medium composition influences herbicide performance for container nursery stock. American Nurseryman 153(2): 11, 122-124.

(275) Jacobsen, S. and K. M. Walls (1987). The phytotoxic effects of isoxaben and ornamental plants and nonbearing trees and vines. Proceedings of the California Weed Conference(39th): 20-21.

(276) Smith, E. M. and S. A. Treaster (1992). Efficacy, phytotoxicity and root response of container-grown landscape plants to repeat applications of pre-emergence herbicides. Special Circulation Ohio Agricultural Research and Development Centre. Ornamental Plants a Summary of Research(140): 5-8.
This study evaluated weed control, foliage injury, and root toxicity from multiple applications of Ronstar, Rout, OH-2 and Gallery over two growing seasons on landscape plnats. Weed control was excellent in all treatments, and foliar injury limited to spirea from Rout and Gallery. Rout injury was noted on azalea and spirea only from more than one application of Rout, OH-2 and Gallery.

(277) Hogue, E. J. and W. Peters (1994). Weed control in a newly planted high density apple orchard. Acta Horticulturae(363): 147-151.
Residual herbicides were evaluated on first year growth and second year yield as well as on tolerance of McIntosh/M.9 to a range of rates of simazine and metribuzin. In the first experiment, the combination of simazine at 1 kg/ha plus pendimethalin at 3 kg/ha provided excellent weed control and better growth than in the hand weeded check, but yields were not improved by this or seven other herbicide treatments. In the second experiment, the highest rates of both chemicals caused some leaf injury but tree growth in the year of planting was not affected. However, blossom count the following spring was reduced by all chemical treatmetns. Although the blossom count was reduced, yield was only reduced with the two highest rates of simazine.

(278) Weller, S. C., J. B. Masiunas, et al. (1984). Evaluation of oxyfluorfen formulations in container nursery crops [Preemergence herbicide, for weed control, Cotoneaster apiculatus, Euonymus fortunei, Juniperus horizonatilis]. HortScience 19(2): 222-224.
Three formulations of oxyfluorfen, 25% wettable powder, 1% granular, 0.24 kg liter^{-1} emulsifiable concentrate, and 2% G oxadiazon were compared for weed control and their effects on growth of Cotoneaster apiculatus Rehd. and E.H. Wils., Euonymus fortunei (Rurcz.) Hand.-Mazz. 'Colorata', and Juniperus horizontalis Moench. 'Glenmore'. Both herbicides provided acceptable weed control at recommended rates. The EC formulation of oxyfluorfen provided the best weed control, but injury to euonymus and juniper was also most severe with the EC, while injury to cotoneaster was most severe with the EC and G.

(279) Bennett, W. J. (1975). Granular herbicide combinations in nursery beds. Proceedings of the Northeasten Weed Science Society 29: 357-358.
Combinations of granular herbicides were mixed prior to application to nursery beds in two Massachusetts nurseries. Simazine 4G at 1 lb. ai/A. was combined with several herbicides and applied on duplicated plots in June 1974. Herbicides mixed with simazine included profluralin 2G at 2 lbs. and 3 lbs. si/A, trifluralin 5G at 2 lbs. ai/A, napropamide 10G at 4 lbs. ai/A, diphenamid 5G at 4 lbs. ai/A. All combinations resulted in satisfactory weed control through August 1974. No injury was noted in any of the plant species treated.

(280) Elmore, C. L. and D. J. Boquist (1987). Evaluation of preemergent herbicides in nursery container ornamentals. Western Society of Weed Science. Research Progress Report: 86-87.

(281) Haramaki, C. and L. J.-Kuhns (1983). Post transplant herbicide applications on selected woody liners. Proceedings of the Annual Meeting of the Northeastern Weed Science Society(37th): 335-338.
Combinations of alachlor and simazine, metolachlor and simazine, and napropamide and oxadiazon; and oryzalin and oxyfluorfen alone gave good to excellent weed control over a 10 week period. Barberry had a good vegetative growth when treated with oryzalin at 2 and 8 pounds per acre. Common boxwood had less growth and some injury when treated with alachlor and simazine and also metolachlor and simazine but not with napropamide and oxadiazon at recommended rates. Oxyfluorfen sprays injured cranberry cotoneaster. Bluerug juniper had good vegetative growth with no injury when treated with napropamide and oxadiazon. Japanese pachysandra had some injury from alachlor and simazine, metoalchlor and simazine, and napropamide and oxadiazon combinations and with oxyfluorfen. Laland pyracantha had some injury on the older leaves but not the new subsequent growth when sprayed with metolachlor and simazine at the recommended rate. Winterjasmine had good vegetative growth with no injury when sprayed with oryzalin at 2 pounds per acre.

(282) Keese, R. J., N. D. Camper, et al. (1994). Herbicide runoff from ornamental container nurseries. J environ qual 23(2): 320-324.
Runoff and pond water samples from a container nursery that recycles water for irrigation were tested for movement of herbicides from the site of application. Residues of oryzalin [4-(dipropylamino)-3, 5-dinitrobenzene-sulfonamide], pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2, 6-dinitrobenzamine]) and oxyfluorfen [2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene], active ingredients in the granular formulations of Rout [2-chloro-1-(3-ethoxy-4-notrophenoxy)-4-(trifluoromethyl) benzene+3,5-dinitro-N(4 N(4)-dipropylsulfanilamide] and OH-2 (Ornamental Herbicide-2), were evaluated. Herbicides were applied at labeled rates and followed by irrigation. Water samples were collected, herbicides were extracted by solid phase on and analyzed by reverse phase high pressure liquid chromatography with ultraviolet (UV) detection. Maximum herbicide residues were detected within the first 15 min of water runoff; oryzalin residues were the greatest of the three herbicides evaluated (4 mg L(-1) water at 15 min) and showed rapid decreases thereafter. Herbicide residues detected in pond samples decreased over time until the detection limit was reached (2 wk following application). A microplot study was to evaluate the effects of plastic, woven fabric or gravel bedcovers on herbicide movement. Plastic and fabric allowed greatest movement of oryzalin and pendimethalin, while gravel significantly retained and retarded movement of all three herbicides. Results indicate that bedcover composition plays a significant role in the movement of herbicide from the site of application. Release of active ingredient from granular formulations was evaluated; dinitroanilines.

(283) Ryan, G. F. (1982). Weed control in nursery containers. Comb Proc Int Plant Propagators Soc 31: 83-85.

(284) Gibson, J. D. (1985). Research explores possibilities for container weed control. American Nurseryman 162(8): 63, 66-69.

(285) Schleicher, L. C. (1992). Efficacy and dissipation of pendimethalin and dithiopyr in a perennial ryegrass turf. Agronomy. Lincoln, Nebraska, University of Nebraska: 102.

(286) Fretz, T. A. and W. J. Sheppard (1978). USB-3153 and oxyfluorfen: two new experimental herbicides for container nursery stock [Digitaria sanguinalis, Amaranthus retroflexus, Chenopodium album, ornamentals]. Research Circular: Ohio Agriculture Research Develpment Centre(236): 48-50.

(287) Bing, A. (1983). The effect of time of watering after herbicide spray application on phytotoxicity to container grown nursery plants. Proceedings of the Annual Meeting of the Northeastern Weed Science Society(37th): 327-330.

(288) Kuhns, L., G. Twerdok, et al. (1983). The effects of time of herbicide application on conifer seedbeds Colorado spruce, Picea pungens, Douglas fir, Pseudotsuga menziesii. Proceedings Annual Meeting of the Northeastern Weed Science Society(37th): 313-317.
Seeds of Colorado spruce (Picea pungens Engelm.) and Douglas fir [Pseudotsuga menziesii (Mirb.) Franco] were sown into 3.9 l containers of an amended, steam pasteurized 1 soil:1 sand: 1 peat medium. Additional containers of the same medium were sown with seeds of four common weeds. Conifer and weed seeds were covered with a steam pasteurized mix of 1 sand: 1 peat. Bifenox, oxyfluorfen, napropamide, and napropamide + oxyfluorfen were applied at three rates prior to conifer emergence and one, two and three weeks after emergence. Bifenox and napropamide provided poor weed control, oxyfluorfen provided good control, and napropamide + oxyfluorfen provided excellent control. Both conifer species were more tolerant of bifenox and oxyfluorfen and less tolerant of napropamide when they were applied prior to emergence. Oxyfluorfen caused considerable injury when applied anytime during the three weeks following emergence. Bifenox was safe when used at 3.3 kg/ha or less two weeks after germination. Naprpamide was safe when used at 2.2 kg/ha or less at anytime before or after germination. Colorado spruce was more sensitive to the herbicides than Douglas fir.

(289) Mahnken, G. E., W. A. Skroch, et al. (1994). Metolachlor and simazine leaching through horticultural substrates. Journal of Environmental Horticulture 12(1): 55-58.
This study was designed to determine whether differences existed in the amount of Derby (metolachlor and simazine) leached through four substrates used in container production. Substrate compositions (by vol) used in this study were 3:1 redwood bark:sand, 2:1:1 redwood bark:Yolo loam:sand, 3:1 pine bark:sand, and1:1 composted hardwood bark:pine bark. Substrates were packed into #3 containers, and 4.5 kg ai/ha (4 lb ai/A) of metolachlor and 1.1 kg ai/ha (1 lb ai/A) of simazine were applied to the containers as a granular formulation. Containers were leached with 2.7 cm (1.06 in) of water per day, and leachate samples were collected 0, 1, 2, 4, 8, and 16 days after herbicide application. Both herbicides were detected in the redwood bark:sand leachate on the day of herbicide application, and concentrations increased over time but appeared to level off between day 8 and day 16. Metolachlor and simazine were detected in the redwood bark:Yolo loam:sand leachate 4 days after application, and concentrations of both herbicides increased over time. Metolachlor and simazine were detected in a few leachate samples from the hardwood bark: pine bark and pine bark:sand substrates. Substrate ranking based on the amount of herbicide lost was 3:1 redwood bark:sand > 2:1:1 redwood bark;Yolo loam:sand > 1:1 hardwood bark:pine bark > 3:1 pine bark:sand.

(290) Setyowati, N., L. A. Weston, et al. (1995). Evaluation of selected preemergence herbicides in field-grown landscape crops in Kentucky. Journal of Environmental Horticulture 13(4): 196-202.
Research was conducted during 1990 and 1991 at the Horticultural Research Farm in Lexington, Kentucky, to evaluate the efficacy of herbicides available for use on woody landscape plants (simazine and oryzalin), newly labelled herbicides (isoxaben, isoxaben plus oryzalin, metolachlor and metolachor

plus simazine) and those not widely labelled for the mursery industry (oxyfluorfen and dithiopyr). Herbicide phytotoxicity was also evaluated in 10 species of woody nursery crops. Results 6 WAT (weeks after treatment) indicated that the standard of simazine at 1.1 kg ai/ha plus oryzalina t 3.3 kg ai/ha provided adequate control of most common broadleaf weeds (98%) and annual grasses (98%) but not yellow nutsedge (31%). Isoxaben plus oryzalin at 4.2 kg ai/ha (DF formulation) and isoxaben plus trifluralin at 4.2 kg ai/ha (granular formulation) gave excellent full-season control of nearly all broadleaf and grass weeds with the exception of galinsoga and field bindweed. In addition, yellow nutsedge control was acceptable, ranging form 63 to 96% in these treatments. Isoxaben alone also provided excellent broadleaf control (93%) 6 WAT in 1990 but poorer (<70%) control of giant foxtail, galinsoga, and velvetleaf by 12 WAT. Dithiopyr (granular formulation) provided excellent full-season residual contol of broadleaf weeds, nutsedge and grasses at the highest rate of 2.2 kg ai/ha. Oxyfluorfen at the higher rate (2.2 kg ai/ha) also controlled all species except yellow nutsedge. Poor broadleaf control was obtained 12 WAT with 3.3 kg ai/ha metolachlor or metolachlor plus simazine ar rates up to 4.4 kg ai/ha in both 1990 and 1991. Pronamide at 2.2 kg ai/ha did not provide adequate control of either broadleaf or grasses at 6 or 12 WATT. No visisble phytotoxicity to woody ornamentals was observed in either season up to 8 weeks after application. However, growth reductions were noted in both common lilac and red oak stem or trunk diameter following treatment with isoxaben at 1.1 kg ai/ha.

(291) Work, T. M. and R. H. True (1981). The Effect of Dual on the Flavor of Riced Baked Potatoes. American Potato Journal 58(7): 383-384.
Samples of Katahdin potatoes (Solanum tuberosum) from untreated and Dual 8E-treated plots (4 lb ai/A applied at the first hilling) were evaluated for flavor by a sensory panel of 21 members. No off-flavor was associated with the Dual-treated baked potatoes.

(292) Collins, H. A. and C. Buchholz (1981). Metolachlor and Metolachlor + Simazine for Use on Ornamentals. Proceedings of the Northeastern Weed Science Society 35: 246-247.
Metolachlor and metolachlor + simazine have been observed to be efficacious on several weed species, while exhibiting selectivity to many woody ornamentals. Researchers have evaluated metolachlor and metolachlor plus simazine applied prior to wed emergence in both containerized and field grown ornamentals. These results center on field grown ornamentals, many of which involve liners. Rates of metolachlor evaluated ranged from 0.6 to 18 kg/ha. Rates of simazine ranged form 0.6 to 4.5 kg/ha. All herbicide rates were not evaluated on each species of ornamentals mentioned herein.
Examples of ornamentals exhibiting tolerance to selected rates of metolachlor and metolachlor plus simazine as broadcast or directed spray treatments or as broadcast granular treatments are shown in Table 1.

(293) Beste, C. E. and J. R. Frank (1990). Influence of metolachlor on Ilex crenata Thunb. for control of yellow nutsedge. Journal of Environmental Horticulture 8(2): 58-60.
A single spring of fall application of Dual 8E (metolachlor) at 13.5 kg/ha to newly planted 'Hertzii' and 'Howardi' Japanese holly caused 15 to 18% injury during the first few weeks after treatment. No additional injury or reduced growth was evident with any Dual treatments 4 weeks after application. Applications of Dual at rates up to 13.5 kg/ha to established 'Hertzii' holly did not cause injury or affect plant height x width. Dual at 4.5 kg/ha to 13.5 kg/ha was adequate to control yellow nutsedge (Cyperus esculentus L.)

(294) Lange, A. H. and E. K. Stillwell (1989). Tree phytotoxicity symptoms with metolachlor in two central valley soils. Research Progress Report of the Western Society of Weed Science: 160-162.

(295) Kent, R. A. (1991). Canadian water quality guidelines for metolachlor. Inland Waters Directorate. Scientific Series.(184): iii-34.
A literature review was conducted on the uses, fate, and effects of metolachlor on raw water for drinking water supply, freshwater aquatic life, agricultural uses, recreational water quality and aesthetics, and industrial water supplies. The information is summarized in this publication. From it, water quality guidelines for the protection of specific water uses are recommended.

(296) Gilliam, C., G. Wehtje, et al. (1985). Preemergence weed control in field-grown nursery stock. Proceedings of the Annual Meeting of the Arkansas State Horticulture Society(106): 73-78.

(297) Gallitano, L. B. and W. A. Skroch (1993). Herbicide efficacy for production of container ornamentals. Weed Technology 7(1): 103-111.
A study was conducted to evaluate efficacy of 17 PRE herbicides on seven weed species that are important competitors in container-grown ornamentals. Treatments included napropamide, metolachlor, acifluorfen, lactofen, oxyfluorfen, oryzalin, pendimethalin, prodiamine, trifluralin, isoxaben, oxadiazon, simazine and combination products. Control was evaluated by counting weed seedlings 42, 202, and 249 d after treatment. Some treatments provided nearly total control of less than 1.0 seedling per container at each rating over two years. Those treatments were: common groundsel - diphenyl ethers, isoxaben, oxadiazon, owyfluorfen + oryzalin, and oxyfluorfen + pendimethalin; prostrate spurge - pendimethalin, prodiamine, prodiamin-ABD, trifluralin, oxadiazon, isoxaben + oryzalin, and methazole + prodiamine; common chickweed - isoxaben and isoxaben + oryzalin; hairy bittercress - oxyfluorfen, pendimethalin, prodiamine, prodiamine-ABE, oxadiazon, oxyfluorfen + oryzalin, oxyfluorfen + pendimethalin, and methazole + prodiamine; common ragweed - oxyfluorfen, prodiamine-ABD, methazole + prodiamine; Virginia pepperweed - lactofen, oxyfluorfen, oryzalin, pendimethalin, prodiamine, prodiamine-ABD, isoxaben, oxadiazon, oxyfluorfen + oryzalin, oryzalin + pendimethalin, isoxaben + oryzalin, and methazole + prodiamine; horseweed - oxyfluorfen, dinitoanilines, ocadiazon, oxyfluorfen + oryzalin, oxyfluorfen + pendimethalin, isoxaben + oryzalin, and methazole + prodiamine.

(298) Jooste, J. v. d. and J. J. Van Biljon (1976). Metolachlor + atrazine a combination pre-emergence herbicide for broad spectrum weed control in maize. Gewasproduksie/Crop Production 5: 85-90.
Metolachlor, a new selective pre-emergence herbicide for use in maize with excellent grasskilling properties and considerable activity on Cyperus esculentus, has been combined with atrazine to produce broad spectrum pre-emergence weed control in maize. A 1:1 ratio of the two compounds proved optimal. A flowable formulation in water containing 250 g atrazine per litre was developed and given the trade name Gesagram. This formulation gives wide spectrum selective weed control in maize with a residual action of up to 12 weeks on most weeds. A shallow cultivation up to 6 weeks after application does not materially affect the residual action. The effect of soil and climatic conditions on the selectivity and activity with specific reference to the control of Cyperus esculentus are discussed.

(299) Wilcut, J. W., C. H. Gilliam, et al. (1989). Grass control in container-grown ornamentals with pre- and postemergence

herbicide combinations. HortScience 24(3): 456-459.
Control of large crabgrass [Digitaria sanguinalis (L.) Scop.] and goosegrass [Eleusine indica (L.) Gaertn.] was evaluated with the preemergence herbicides oryzalin(Surflan), oxyfluorfen (Goal), and metolachlor (Dual) and the postemergence herbicides quizalofop (Assure), fenoxaprop-ethyl (Whip), haloxyfop (Verdict), poppenate-methyl (Trophy), fluazifop-P (Fusilade 2000), and sethoxydim (Poast) when applied alone or in combination. Oryzalin conbinations provided maximum preemergence control compared to oxyfluorfen or metolachlor combinations. Greatest preemergence and postemergence control was obtained with oryzalin or metolachlor applied with poppenate-methyl. Antagonism of preemergence or postemergence control occurred with several conbinations of preemergence and postemergence herbicides. In some instances, control was enhanced by using other herbicide combination.

(300) Corell, T. E. and A. Bing (1983). Effective weed control practices that minimize soil erosion. Proceeding of the Annual Meeting of the Northeastern Weed Science Society(37th): 347-351.
Chemical weed control programs for commercial nursery growers evolved that provided effective weed control yet left field soils exposed to severe wind and water erosion. This report outlines efforts to tailor herbicide programs and grower application practices to attain satisfactory weed control with minimal soil erosion.

(301) Williams, D. B. and J. Sanders (1984). The origin and dissemination of weed seed in container--grown nursery stock. Proceedings of the Southern Nurserymen's Association Research Conference(29th): 244-251.

(302) Barnes, C. J., T. L. Lavy, et al. (1992). Leaching, dissipation, and efficacy of metolachlor applied by chemigation or conventional methods. J environ qual 21(2): 232-236.
Field leaching, dissipation, and efficacy of metolachlor (2-chloro-N(2-ethyl-6-methylphenyl)-N-(methoxy-1-methylethyl)acetamide) were evaluated for 8 wk when the herbicide was applied by conventional and chemigation methods to a Taloka silt loam soil (coarse-silty, mixed, nonacid, thermic Mollic Albaqualf). Laboratory studies were conducted to evaluate adsorption and mobility of the herbicide in five soil depths ranging from 0 to 38 cm. Metolachlor leaching below 30 cm was not observed in either year, regardless of application method. Dissipation rates of metolachlor were not influenced by application method either year. Efficacy of the herbicide was not affected by method of application. Metolachlor sorption was highest in the 0- to 8-cm soil depth of the Taloka silt loam with an organic matter content of 1.1%.

(303) Blumhorst, M. R., J. B. Weber, et al. (1990). Efficacy of selected herbicides as influenced by soil properties. Weed Technology 4(2): 279-283.
Field experiments were conducted on six loam and sandy loam soils to study the influence of various soil parameters on atrazine, cyanazine, alachlor, metolachlor, and pendimethalin efficacy. Herbicidal activity was highly correlated to the soil organic content. Humic matter content was equally or better correlated (r=0.70 to 0.91) with herbicide bioactivity than was organic matter content (r=0.66 to 0.84). Regression equations were determined which allow herbicide rate recommendations for 80% weed control to be calculated based on soil humic matter or organic matter levels.

(304) Weber, J. B., H. D. Coble, et al. (1981). Soil tests and herbicide rate recommendations for metolachlor and alachlor in agronomic and horticultural crops. Proceedings of the Southern Weed Science Society(34th): 265-273.
Accurate herbicide recommendations are necessary to prevent herbicide injury and carryover, give adequate weed contol and provide maximum profits for growers. Currently soil applied herbicide rate recommendations ate generally based on soil texture and organic matter content of the soil and could be improved substantially. Soil organic matter analyses of selected North Carolin and U.S. soils done by several soil testing laboratories showed a large variation in organic matter content with the absolute error ranging from 200 to 600%. This variation may be attributed to differences in method of analysis. A standardized soil test which could be used to accurately predict the rate of soil applied herbicides for optimum weed control is nedded. Extraction of soil humic matter from soil with 0.2N NaOH + 0.02M DTPA (diethylenetriamine pentaacetic acid, pentasodium salt) solution was highly correlated with standard oxidizable organic matter analysis as normally done with 4N chromic acid. Weed control performance from preemergence application of metolachlor and alachlor in field tests was highly correlated with organic matter content of the soil, as expressed in % humic matter or % oxidizable organic matter. The % humic matter is a more desirable method since the waste products from the analyses can be disposed of in municipal sewage systems, while chromic acid wastes form oxidizable organic matter analyses cannot.

(305) Dev, J., J. N. Singh, et al. (1992). Development and use of a soil bioassay for pendimethalin and fluchloralin. Tropical Pest Management 38(1): 22-24.
A root bioassay with sorghum (Sorghum bicolor L. cv. CSH 5) and wheat (Triticum aestivum L. cv. Sonalika) was developed for detecting the concentration of pendimethalin and fluchloralin in soils. The reduction in root growth of pregerminated seeds after 48 h was concentration dependent in both the herbicides having the range form 0.01 to 10.0 ppm in 20 ml water added to 100 g soil. Residue activity of both pendimethalin and fluchloralin were detected for up to 80 days after application of 1.5 kg/ha pendimethalin and 2.25 kg/ha fluchloralin in the 0-5 cm soil layer during 2 years when these herbicides were applied to field crops of mint.

(306) Gasper, J. J., J. R. Street, et al. (1994). Pendimethalin efficacy and dissipation in turfgrass as influenced by rainfall incorporation. Weed Science 42(4): 586-592.
A 2-yr field study was conducted to determine effects of posttreatment irrigation timing on pendimethalin efficacy and dissipation in turfgrass. Factors investigated included herbicide rate, formulation, and the interval between pendimethalin application and the initial posttreatment irrigation. Plots received an initial posttreatment irrigation of 1.25 cm 0, 7, 14, 21, and 28 d after treatment Pendimethalin efficacy on smooth crabgrass was evaluated, and turfgrass foliage and the upper 2.5-cm layer of soil were periodically assayed for pendimethalin residues. Pendimethalin 1.71% granular provided better weed control than pendimethalin 60% wettable powder at all rates, irrigation events, and years. Efficacy of granular pendimethalin was not affected by a delay in posttreatment irrigation, whereas efficacy of pendimethalin in the wettable powder formulation was reduced when irrigation was applied later than the day of treatment. Chromatographic analyses indicated that an average of 54% of the applied pendimethalin (wettable powder formulation) was retained on turfgrass foliage immediately after treatment, compared to 9% for the granular formulation. Soil residue analyses confirmed that a greater proportion of applied pendimethalin reached the soil surface immediately after treatment in the granular formulation than in the wettable power formulation.

(307) Bond, W. (1986). Weed control in vegetables with pendimethalin. Aspects of Applied Biology(12): 211-221.
In field experiments on a sandy loam soil, pendimethalin applied pre- and post-emergence controlled many important annual weeds other than Compositae. Weed control with pendimethalin alone was good but was improved by the addition of other herbicides. Pre-emergence treatments in umbelliferous crops caused crop injury in one carrot trial only. Onions, leeks, and peas were the crops most tolerant to post-emergence applications. There was no adverse effect on yield of onions sprayed at a range of growth stages, and post-planting treatment of block-sown onions also caused no crop damage.

(308) Miranda, E. and F. D. Rauch (1989). Response of hemigraphis to rout herbicide. Research Extension Series. College of Tropical Agriculture and Human Resources, University of Hawaii Cooperative Extension Service(103): 6-7.

(309) Miranda, E., F. D. Rauch, et al. (1989). Rout herbicide evaluation. Research Extension Service, College of Tropical Agriculture and Human Resources, University of Hawaii Cooperative Extension Service(103): 3-5.

(310) Frank, J. R. (1980). Nursery weed control with oxyfluorfen, prodiamine, oryzalin, glyphosate, and paraquat. HortScience 15(3,sect.2): 413.
Oxyfluorfen, prodiamine, or oryzalin were applied in a newly planted nursery of Hicks yew, Japanese holly, Hershey red azalea, and Andorra juniper in May and followed by applications of glyphosate (4.5 kg/ha) or paraquat (1.1 kg/ha) later in the season. Plots treated with oxyfluorfen (4.5 kg/ha) averaged less than 20% weed cover 66 days after treatment. Plots treated with oryzalin (2.2 kg/ha) had 25% weed cover at 52 days and plots with prodiamine (4.5 kg/ha) had 47% weed cover at 28 days. In September plots treated 3 times with glyphosate or paraquat averaged 11% and 62% weed cover respectively. Weed cover varied from 7% to 12% in the most effective treatments (oxyfluorfen or prodiamine at 2.2 or 4.5 kg/ha or oryzalin at 2.2 kg/ha followed by 3 treatments of glyphosate). Crop size, crop quality or marketability were not affected by any treatment.

(311) Camper, N. D., T. Whitwell, et al. (1994). Herbicide levels in nursery containment pond water and sediments. Journal of Environmental Horticulture 12(1): 8-12.
Herbicide movement from broadcast granular applications via runoff waters into containment ponds was monitored over a two-year period. The nursery site was approximately 20 ha and contained all runoff waters and recycled it for irrigation. Levels of pendimethalin, oryzalin and oxyfluorfen applied as either OH-2 or Rout herbicides were determined in containment pond water and sediment. Herbicides were extracted by a solid-phase column method and analyzed by HPLC with confirmation by GC-MS. Generally, low herbicide levels (highest level detected was 0.013 micrograms/ml in water and 12 micrograms/g in sediment) were detected compared to quantities applied (12 to 50 kg ai per year). Results showed that herbicide levels did not accumulate in containment ponds following repeated applications and there was no correlation of herbicide levels detected with amount or timing of herbicide applications.

(312) Fretz, T. A., J. J. Koncal, et al. (1980). Evaluation of oxyfluorfen for weed control and phytotoxicity on container grown nursery stock. Research Circular Ohio Agriculture Research and Development Centre(253): 31-33.
Oxyfluorfen-2G was evaluated for weed control and phytotoxicity on nine species of container grown nursery stock. Treatments included oxyfluorfen-2G applied singly at rate of 1.0, 2.0, 4.0 and 8.0 lb/A and in combination at 2.0 lb ai/A with simazine-4G at 1.0 lb ai/A, oxadiazon-4G at 4.0 lb ai/A, oryzalin-5G at 4.0 lb ai/A, and prodianine-4G at 3.0 lb ai/A. Oxyfluorfen-2G when applied singly at the recommended rate of 2.0 lb ai/A did not control annual grass of broadleaf weeds. However, when oxyfluorfen-2G was applied at the 2.0 lb ai/A rate in combination with simazine, oxadiazon, oryzalin or prodiamine, weed control was improved, with a minimum of injury observed. Oxyfluorfen-2G at the 2.9 lb ai/A rate in combination with any of the above four herbicides shows promise and should be further evaluated.

(313) Riley, M. B., R. J. Keese, et al. (1994). Pendimethalin and oxyfluorfen residues in pond water and sediment from container plant nurseries. Weed Technology 8(2): 299-303.
A two-year herbicide residue study was conducted at a commercial nursery to determine the presence of herbicide residues in pond water and sediment following normal production cycles. The runoff water from irrigation and rainfall was contained on the nursery and reused for irrigation. The nursery site was approximately 60 ha with two interconnected ponds, one for containment of runoff water and one serving as a source of irrigation water. The most commonly used herbicides were oxyfluorfen plus pendimethalin (granular formulation-OH-2); approximately twice as much herbicide was applied during the second year of the study. Herbicide levels found in pond water and sediment were approximately two-fold greater during the second year corresponding to the increase in active ingredients applied. The highest concentration of oxyfluorfen found in water and sediment was 0.04 micrograms/ml and 4.0 micrograms/g, respectively. The highest concentration of pendimethalin found in water and sediment was 0.0008 micrograms/ml and 14.3 micrograms/g, respectively. In irrigation water samples, the highest concentration of oxyfluorfen and pendimethalin detected was 0.005 micrograms/ml and 0.002 micrograms/ml, respectively.. The herbicides did not accumulate in water or sediment over the two-year period. No landscape plant phytotoxicity problems are likely at the herbicide levels detected in irrigation water samples.

(314) Bing, A. (1979). The Effect of Preemergence Postplant Treatments of Alachlor, Napropamide, Oxadiazon, Oxyfluorfen and Prodiamine on Gladiolus. Proceeding of the Annual Meeting of the Northeastern Weed Science Society 33: 264-269.
Napropamide up to 16 lb/A and prodiamine at 2 and 4 lb/A were safe on gladiolus. Oxadiazon and oxyfluorfen caused leaf burn and greatly reduced the production of gladiolus corms from cormels. Alachlor reduced corm production from cormels and reduced cut flower yield from small corms.

(315) Reeder, J. A., C. H. Gilliam, et al. (1994). Evaluation of selected herbicides on field-grown woody ornamentals. Journal of Environmental Horticulture 12(4): 236-240.
Six herbicides and selected combinations were evaluated on four field-grown woody landsxape crops: live oak, 'Mary Nell' holly, 'Chesapeake' viburnum, and 'Acoma' crapemrytle. All herbicide treatments provided excellent control of goosegrass. Treatments with Predict (norflurazon) provided adequate sicklepod contol. Only Goal (oxyfluorfen)- containing treatments controlled cutleaf eveningprimrose. Predict and Predict treatment-combinations bleached older foliage of crapemyrtle and viburnum when applied in the first year after planting; however, growth was not affected. Holly was not injured by any herbicide treatments. Pendulum (pendamethalin) and Surflan (oryzalin) had similar weed control activity and plant growth with no plant injury.

(316) Ruter, J. M. and N. C. Glaze (1992). Herbicide combinations for control of prostrate spurge in container-grown landscape plants. Journal of Environmental Horticulture 10(1): 19-

22.
Studies were conducted in 1989 and 1990 to evaluate combinations of herbicides for control of prostrate spurge in container grown landscape plants. In 1989, the combination of Ronstar 2G [oxadiazon (2.24 kg/ha)] with Surflan 40 AS [oryzalin (2.24 kg/ha)] or Barricade 65 WG [prodiamine (2.24 kg/ha)] resulted in 95% or better control of prostratespurge. Combintions of Ronstar and Pennant 5G [metalochlor (4.48 kg/ha)] or Rout 3G [oxyfluorfen (2.24 kg/ha)] plus oryzalin (1.12 kg/ha) controlled more than 80% of the weeds after 12 weeks in 1989. Some herbicide treatments containing oryzalin and pendimethalin reduced the root grade of Rhododendron cv. 'Stewartsonian' and Ilex Crenata Thunb. 'Helleri' in 1990. Herbicide treatments in the 1990 study had no effect on growth parameters of Juniperus chinesis L. 'Pfitzeriana Glauca'. Rout was the only herbicide in the 1990 study which reduced the number of prostrate spurge plants per pot in all three landscape species after 10 weeks. Dry weight of prostrate spurge was reduced approximately 3.6 x when Rout was used on 'Stewartsonain' azalea. Improved prostrate spurge control due to certain herbicide combinations did not result in increased foliar growth indices of the species used in this study. Dinitroanaline herbicides should be tested further for crop phytotoxicity and potentioal prostrate spurge control.

(317) Meakin, A. R. and C. Orpin (1984). Oxyfluorfen. Further studies in nursery weed control and species safety. Aspects of Applied Biology 5: 397-407.
Oxyfluorfen is a new broad spectrum contact and residual herbicide which has been used in conifer seed beds, standover seedbeds and in lined out hardy nursery stock. Oxyflourfen controls many difficult grasses and broad leaf weeds including those resistant to simazine. Oxyfluorfen shows a high degree of crop safety.

(318) House, M. and C. E. Whitcomb (1984). Weed control in container nursery stock. Research Report P Agriculture Experimental Station Oklahoma State University(855): 50-51.

(319) Whitcomb, C. E. (1977). A comparison of Ronstar, Lasso and Treflan for weed control in containers [Nursery plants]. Research Report P Agriculture Experimental Station Oklahoma State University(760): 79-83.

(320) Renner, K. A. (1992). Timing of herbicide application and potato hilling. American Potato Journal 69(3): 167-177.
Weed management involving the time of hilling and various herbicide applications was compared. The best weed managemnt program consisted of EPTC at 3.3 kg ai/ha preplant incorporated, followed by metribuzin at 0.6 kg ai/ha applied delayed preemergence, or delayed preemergence applications of metolachlor plus linuron (2.2 + 1.1 kg ai/ha) or metolachlor plus metribuzin (2.2 + 0.6 kg ai/ha) regardless of the time of hilling. Alternatively, postemergence applications of sethoxydim plus metribuzin plus crop oil concentrate at 0.2 plus 0.6 kg ai/ha plus 1.2 L/ha provided excellent season-long weed control regardless of the time of hilling. However, potato yield was reduced in 1 of 2 years by this treatment. Preemergence herbicides applied immediately after planting followed by an early hilling at ground cracking did not provide season-long weed control. The cultivar Atlantic was a better competitor with weeds than Russet Burbank in 1 of 2 years.

(321) Kabashima, J. (1992). Container nursery weed control. Proceedings of the California Weed Conference(44th): 92-95.

(322) Doub, J. P., H. P. Wilson, et al. (1988). Comparative efficacy of two formulations of alachlor and metolachlor. Weed Science 36(2): 221-226.
The efficacies of microencapsulated (ME) and emulsifiable concentrate (EC) formulations of alachlor and metolachlor were compared in petri dish and soil bioassays. At equimolar concentrations, EC-alachlor inhibited shoot growth of barnyardgrass [Echinochloa crus galli (L.) Beauv. #3 ECHCG], large crabgrass [Digitaria sanguinalis(L.) Scop # DIGSA] and fall panicum [Panicum dichotomiflorum Michx # PANDI] more than ME-alachlor. ME- and EC- metolachlor caused simlar effects on the three grass weeds tested. ME- and EC-alachlor in combination caused effects on barnyardgrass shoot growth intermediate to results with either formulation alone. Airdrying and remoistening of alachlor-treated filter paper or soil before sowing barnyardgrass or fall panicum caused greater shoot length and fresh weight reduction than ME- alachlor that was not dried.

(323) Kahn, B. A. and R. J. Schatzer (1992). Economic and horticultural evaluation of chemical and mechanical weed control strategies for cowpea. Journal of the American Society for Horticulture Science 117(2): 255-259.
The herbicides paraquat, trifluralin, and metolachlor were compared for efficacy of weed control in cowpea [Vigna unguiculata (L.) Walp.] with and without cultivation as a supplemental strategy. Herbicides also were compared against a no cultivation-no herbicide treatment (control) and against cultivation without an herbicide. Cultivation had no significant effect on seed yield, biological yield, or harvest index of cowpea. Paraquat, applied before seeding but after emergence of weeds, was ineffective for weed control and usually did not change cowpea yield from that obtained without an herbicide. Trifluralin and metolachlor more than tripled cowpea seed yield compared with that obtained without an herbicide in 1988, when potential weed pressure was 886 g.m-2 (dry weight). The main effects of trifluralin and metolachlor were not significant for cowpea seed yield in 1989, when potential weed pressure was 319 g.m-2 (dry weight). However, in 1989, these two herbicides still increased cowpea seed yield compared with that of the control and increased net farm income by more than $300/ha compared with the income obtained from the control.

(324) Bing, A. (1983). Postplant preemergence weed control on nursery liners, 1982. Proceedings of the Annual Meeting of the Northeastern Weed Science Society(37th): 339-342.
Newly planted nursery liners were very tolerant to preemergence applications of alachlor 15G, napropamide 5G, metolachlor 8E, metolachlor 8E plus simazine 4L and oxyfluorfen 1G granular.

(325) Bing, A. (1983). Tolerance of container grown nursery plants to some preemergence herbicide applications. Proceedings of the Annual Meeting of the Northeastern Weed Science Society(37th): 332-334.
Plants grown in containers were safely treated with the following herbicides: simazine 80WP on rhododendron; metolachlor 8E on viburnum; napropamide 50WP on cotoneaster and dogwood; oxyfluorfen 1G on cotoneaster, azalea, holly and privet.

(326) Haramaki, C. and L. Kuhns (1981). Preemergent herbicides on newly planted lines. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 35: 240-244.
Sprays of alachlor, alachlor plus simazine, metolachlor, metolachlor plus simazine, oxyfluorfen, and prodiamine produced good weed control especially at the higher rates and also the combinations gave excellent weed control. The granular form of oxyfluorfen did not prove as effective as the spray in controlling weeds. All of the Korean azaleas and many of the Laland firethorns had severe transplnat injury. At the lower rates of application common boxwood, cranberry cotoneaster, convexleaf

holly, Baltic ivy, Andorra juniper and purpleleaf wintercreeper had little or no injury. Common boxwood, convexleaf holly, and Baltic ivy exhibited some chlorosis when sprayed with both the alachlor plus simazine combination and the metolachlor plus simazine combination. Oxyfluorfen produced lateral bud distortion in the common boxwood and some necrosis in the convexleaf holly and Baltic ivy.

(327) Warren, S. L. and W. A. Skroch (1991). Evaluation of six herbicides for potential use in tree seed beds. Journal of Environmenatl Horticulture 9(3): 160-163.
Five herbicides, Pennant, Surflan, Devrinol, Ornamental Herbicide 2, and Ronstar, were applied over newly seeded deciduous trees immediately after seeding and Poast was applied when seedlings were actively growing. The trees were river birch, pin oak, willow oak, redbud, flowering dogwood, sugar maple, and sweet gum. No seedlings were damaged by Pennant (4.5 kg/ha) or Poast. OH-2 and Ronstar severly damaged river birch, flowering dogwood, and sugar maple. Surflan damaged sugar maple. Devrinol damaged flowering dogwood. Data herein suggest that each species must be evaluated separately for herbicide tolerance.

(328) Skroch, W. A., C. J. Catanzaro, et al. (1990). Response of Nine Herbaceous Flowering Perennials to Selected Herbicides. Journal of Environmental Horticulture 8(1): 26-28.
Nine herbicides registered for use on turf and ornamentals were applied semiannually for 2 years to 9 species of field grown herbaceous flowering perennials. The herbicides used were Balan (benefin), Betasan (benzulide), Dacthal (DCPA), Devrinol (napropamide), Fusilade (fluazifop), Ornamental Herbicide 2 (oxyfluorfen + pendimethalin), Pennant (metolachlor), Poast (sethoxydim), and Ronstar (oxadiazon). The perennial included fernleaf yarrow, shasta daisy, coreopsis, dianthus, daylily, candytuft, red hot poker, statice, and phlox. Betasan produced no visual phytotoxicity. All other treatments, excluding OH-2, caused less than 20% injury to all species tested. OH-2 caused 40%, 39%, and 30% injury to daylily, yarrow, and red hot poker, respectively. Economically tolerable (less than 25%) injury was exhibited by phlox and shasta daisy treated with OH-2, by daylily treated with Pennant, and by phlox treated with Ronstar. OH-2 increased flowering of coreopsis and statice by 97% and 235% respectively, while it reduced plant area of phlox by 53% and flowering of phlox by 34%. Both Pennant and OH-2 reduced flowering of dianthus by nearly 30%.

(329) Derr, J. F. and B. L. Appleton (1989). Weed control with landscape fabrics. Journal of Environmenatl Horticulture 7(4): 129-133.
Six polypropylene landscape fabrics were compared with black plactic and preemergence herbicides for weed control. Large crabgrass shoots and roots and yellow nutsedge shoots penetrated all of the fabrics tested and developed into large plants. In greenhouse studies, black plactic plus mulch, and pennant (metolachlor) at 4.5 kg ai/ha plus mulch provided equal, or greater conrol of large crabgrass than the landscape fabrics. In the field study, more time was required to hand-weed landscape fabrics covered with mulch than uncovered fabrics. When covered with mulch, hand-weeding time and weed shoot fresh weights were similar for black plastic, surflan (oryzalin) at 2.2 kg/ha, and the landscape fabrics.

(330) Buchholz, C., E. R. Higgins, et al. (1981). Longevity of Control with Metolachlor and Alachlor. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 35: 124-127.
Field experiments in Pennsylvania, New York, and Maryland were conducted to compare the length of control with metolachlor and alachlor. At use rates on sandy loam soils, metolachlor provided 8 weeks of commercial control compared to 2 to 4 weeks for alachlor. On a silt loam soil metolachlor provided 8 to 10 weeks of commercial control compared to less than 4 weeks for alachlor.

(331) Bing, A. (1981). 1980 Preemergence Weed Control in Nursery Liners. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 35: 235-239.
Postplant preemergence treatment of nursery liners was very safe and effective with metolachlor 8E or 15G at 4 lb ai/A, but more effective using metolachlor 8E at 4 lb ai/A plus simazine 4L at 1 lb ai/A. Crop tolerance to oxyfluorfen, napropamide and alachlor was very good. As the rate of simazine is increased over 1 lb ai/A there is increased injury to azalea, euonymous and andromeda. Higher rates of metolachlor may be harmful to azalea.

(332) Lange, A. H. and E. K. Stilwell (1989). The influences of irrigation on the activity of metolachlor when used on the soil in trees. Research Progress Report of the Western Society of Weed Science: 163-166.

(333) Muller, G. and A. Nyffeler (1981). CONCEP (CGA-43089), a safening agent protecting sorghum (Sorghum bicolor) from metolachlor injury Herbicide. Acta Phytopatholgica Academiae Scientiarum Hungaricae 16(1/2): 245-248.

(334) Pusino, A., W. Liu, et al. (1992). Influence of organic matter and its clay complexes on metolachlor adsorption on soil. Pesticide Science 36(3): 283-286.
The absorption of metolachlor, 2-chloro-6'-ethyl-n-(2-methoxy-1-methylethyl)acet-o-toluidide was studied on three soils of various physical and chemical properties. Adsorption isotherms conformed to the Freundlich equation. The k(f) values increased with increasing organic carbon content of the soils. However, variations in k(oc)), values by a factor of four were observed within three natural soils. For a given soil, the k(oc) values remained essentially unchanged after lowering the carbon content by hydrogen peroxide oxidation. These results suggest that the contribution of organic matter to total metolachlor adsorption process is influenced by association mechanisms between organic and inorganic soil constituents. Studies with mixtures of clay and organic matter indicate that the interaction between the two soil components reduces the surfaces available for metolachlor adsorption.

(335) Taylor, K. A. and J. B. Weber (1993). Distribution of metolachlor in a dothan soil as influenced by soil surface management under two irrigation regimes. Proceedings of the Southern Weed Science Society 46: 339-344.
Herbicide mobility in field soil column lysimeters were carried out to determine the effects of two tillage systems, three surface cover types and two water input levels on the distribution of metolachlor in a Dothan soil. Field columns (20.32 cm dia. x 96.52 cm long) were installed with leachate collectors and a ^{14}C-metolachlor/Dual 8E mixture was applied to soil in the columns. After 120 days, the columns were removed and the soil sectioned into twelve 7.6 cm samples by depth. The concentration of herbicide was determined for each depth and leachate collection date. Slightly greater but not significantly different herbicide mobility was observed in the reduced tillage system. Turf treatment resulted in lower herbicide mobility and lower herbicide recovery form the soil than did soybean or fallow treatments which were not different. The irrigation regimes used did not affect the movement or percent of herbicide recovered.

(336) Van Bilion, J. J., H. T. Groeneveld, et al. (1990). Leaching depth of metolachlor in different soils. Applied Plant Science Toegepaste Plantwetenskap 4(2): 46-49.

Leaching studies with metolachlor were done in soil columns with eight South African soils. The clay content of these soils varied from 10 to 51%, organic matter from 0.12 to 2.52% C and cation exchange capacity (CEC) from 1.39 to 32.8 mel100g. Metolachlor at 2.25 kg ai/ha was surface applied followed by 25 mm simulated rain. Japanese millet was planted in segments of the columns to indicate leaching depth. Metolachlor leached as little as 2.5 cm on an adsorptive soil and as much as 12.5 cm on a non-adsorptive soil. Leaching depth of metolachlor was best correlated with CEC (r=-0.94) followed by clay (r=-0.80) and carbon content (r=-0.72).

(337) van Biljon, J. J. and P. C. Nel (1988). Effect of temperature and soil moisture on the selectivity of metolachlor in maize. Applied Plant Science Toegepaste Plantwetenskap 2(1): 1-5.
Two trials were carried out in pots in growth chambers to evaluate the effect of temperature and soil moisture on the selectivity of metolachlor on drift sand soils of the Orange Free State. In the first trial, three temperature regimes (20/10, 25/15, and 30/20 ^{o}C day/night) were used, while the soil was kept at field capacity (15% moisture). The second trial comprised two soil moisture levels (7.5 and 15%) and two temperature regimes (20/10 and 30/20 ^{o}C day/night). The metolachlor rate used in both trial were 0, 1, 2, 4, and 8 mg/kg. Phytotoxicity expressed as a percentage reduction in plant growth (height and dry mass) was most severe at 30/20 ^{o}C day/night. However, the smallest plants occurred at 20/10 ^{o}C day/night with high application rates of metolachlor. The effect of metolachlor on plant growth in this soil at 50% field capacity did not differ dramatically from the effect at field capacity.

(338) Clay, S. A., W. C. Koskinen, et al. (1995). Alachlor and metolachlor movement during winter and early spring at three midwestern sites. Journal of Environmental Science and Health, Part B, Pesticide food contaminants and agricultural wastes B30(5): 637-650.
This study was undertaken to empirically assess alachlor and metolachlor movement in soils during winter and early spring. Alachlor and metolachlor were applied to frozen soils in late November or early December at Rosemount, MN and Aurora and Beresford, SD. Soils were samples in February, March, and April or May and dissected incrementally. Herbicides moved from the surface into the soil at each site. Herbicide redistribution was greatest at the last sampling date when alachlor was measured to 105 cm. Metolachlor was less mobile than alachlor with most remaining at or above the 15 cm depth. These data indicate that most herbicide leaching occurred during the spring with water supplied by snowmelt, the melting frost lens, or spring rains.

(339) Koterba, M. T., W. S. L. Banks, et al. (1993). Pesticides in shallow groundwater in the Delmarva Peninsula. J environ qual 22(3): 500-518.
A regional study of the areal and depth distribution of pesticides in shallow groundwater in the Delmarva Peninsula of Delaware, Maryland, and Virginia was done to (i) relate the pesticides detected to landscape and shallow subsurface features, and (ii) evaluate aquifer vulnerability and the potential contamination of drinking-water supplies. Water samples collected at 100 wells from 1988 to 1990 were analyzed for concentrations of 36 pesticides, four metabolites, and other constituents. The most commonly detected residues were atrazine, cyanazine, simazine, alachlor, metolachlor, and dicamba. Concentrations were low, few exceeded 3 microgram L-1. Most detections correlate with the intensive use of these herbicides in three widely distributed and commonly rotated crops-corn (Zea mays L.), soybean [Glycine max (L.) Merr.], and small grain-particularly if grown in well-drained soils. Most detections occurred in samples collected from shallow wells screened within 10 m of the overlying water table. The shallow depth distribution of most residues is consistent with their suspected history of use (ca. 20 yr), and patterns in shallow groundwater flow in the surficial aquifer in the study area. The areal and depth distributions of detectable residues in groundwater did not correlate with a vulnerability index, nor any of the component scores developed to estimate that index using the DRASTIC method. The shallow depth of most detections also indicates why few samples from water-supply wells in this study had measurable concentrations of pesticides; most supply wells are deeper than 10 m below the water table. The low number of contaminated samples from supply wells implies that deep groundwater currently (1992) used for drinking generally does not contain detectable pesticide.

(340) Ritter, W. F., R. W. Scarborough, et al. (1994). Herbicide leaching in Coastal Plain soil. Journal of Irrigation and Drainage Engineering 120(3): 634-649.
The movement of atrazine, simazine, cyanazine, and metolachlor was studied for two years under conventional tillage and no-tillage corn. Ground water and soil samples were analyzed for the herbicides. Atrazine and simazine were detected in the ground water more frequently than metolachlor or cyanazine. In 1987, the herbicides were leached to the ground water nine days after they were applied when 31.5 mm of rainfall occurred. At the 3.0 m depth atrazine concetrations ranged from 0 to 17 micrograms/L. These was no significant difference in herbicide movement between conventional tillage and no tillage. The frequency of the herbicides detected in the ground water was directly related to the soil half-life of the herbicide. Concentrations of the herbicides detected in the ground water were not related to the water solubility of the herbicide. The research demonstrates pesticides may move to shallow ground water by macropore flow in the sandy soils of the Mid Atlantic states if sufficient rainfall occurs shortly after they are applied.

(341) Ritter, W. F., R. W. Scarborough, et al. (1994). Contamination of groundwater by triazines, metolachlor and alachlor. Journal of Contaminant Hydrology 15(1/2): 73-92.
The movement of triazines (atrazine, simazine, cyanazine), metolachlor and alachlor were studied in continuous irrigated corn in an Evesboro loamy sand soil. Both no-tillage and conventional tillage treatments were used. Atrazine and simazine were detected in the groundwater more frequently than cyanazine and metolachlor. Alachlor, atrazine and simazine moved rapidly to the groundwater if sufficient rainfall occurred shorly after they were applied. Alachlor concentrations ranged from 4.0 to 15.0 ppb and atrazine concentrations ranged from <1.0 to 54 ppb. Metolachlor was detected in the groundwater more frequently than cyanazine. Metolachlor concentrations range from <1.0 to 12.0 ppb and cyanazine ranged from <1.0 to 29.0 ppb. There was no large differences in pesticide movement between conventional tillage and no-tillage.

(342) Richards, R. P. and D. B. Baker (1990). Estimates of human exposure to pesticides through drinking water: a preliminary risk assessment. Long Range Transport of Pesticides. D. A. Kurtz. Chelsea, Lewis Publishers, Inc.: 387-403.

(343) Glotfelty, D. E., G. H. Williams, et al. (1990). Regional atmospheric transport and deposition of pesticides in Maryland. Long Range Transport of Pesticides. D. A. Kurtz. Chelsea, Lewis Publishers, Inc.: 199-221.

(344) Lau, Y. L., D. L. S. Liu, et al. (1995). Volatilization of

metolachlor from water. Journal of environmental science and health, Part B, Pesticide food contaminants and agricultural wastes B30(5): 605-620.
The volatilization of metolachlor from water was studied in the laboratory and in an outdoor open-channel experiment. As expected, volatilization was not significant at temperatures < or = to 25 ^{0} C. However, at temperatures > or = to 30 ^{0} C, there was significant volatilization. This increased volatility reflected the rapid increase of the Henry's law constant with temperature. Additional experiments indicated that aeration of water significantly accelarated volatilization losses. Such air-stripping may be important in very turbulent streams and rivers and when water flows over hydraulic structures such as weirs. The experiments reported here indicate the importance that ecosystem-specific characteristics can have on the persistence of environmental contaminants.

(345) Southwick, L. M., G. H. Willis, et al. (1990). Atrazine and metolachlor in subsurface drain water in Louisiana. Journal of Irrigation and Drainage Engineering 116(1): 16-23.
Atrazine and metolachlor are applied preemergent to corn in plots that are either drained (10-cm plastic tubes 1-m deep) or undrained. Herbicide concentrations in the soil profile down to 30 cm and in the drain water are measured for 243 days. The pesticides show a steady diappearance from the soil with pseudo first-order half-lives (no difference between drained and undrained plots) in the top 2.5 cm of soil of 35-36 days for atrazine and 20-23 days for metolachlor. Total loss of atrazine through soil leaching amounts to 0.038% of the application rate; 97% of this loss occurs within 78 days after application during a period of 530 mm of rain. All (0.13% of that applied) of the metolachlor in the drain water is observed within 59 days after application. The results of the study illustrate the strong correlation between pesticide soil persistence, water solubility, rainfall timing, and pesticide leaching through soil.

(346) Johnson, R. M. and J. J. Fuhrmann (1993). Degradation of atrazine and metolachlor in subsoils from an Atlantic Coastal Plain watershed. Soil Sience Society of America Special Publication(32): 27-31.

(347) Griffin, J. L., J. F. Robinson, et al. (1984). Potential carryover of Dual and Lasso in rice. Annual Progress Report Louisiana Agricultural Experimental Station(76): 317-320.

(348) Koncal, J. J., S. F. Gorske, et al. (1981). Leaching of EPTC, alachlor, and metolachlor through a nursery medium as influenced by herbicide formulations. HortScience 16(6,sect.1): 757-758.
Granular and tablet formulations of EPTC, alachlor, and metolachlor were evaluated for leaching characteristics in nursery containers. The tablet formulations generally controlled the release rate of the herbicides so leaching was not a major problem. Granular formulations of the same herbicides readily leached through the medium. EPTC did not release at a favorable rate from the tablet formulation.

(349) Gaynor, J. D., D. C. MacTavish, et al. (1992). A GC/MSD method for the analysis of metolachlor in cabbage, broccoli, and tomato. Communications in Soil Science and Plant Analysis 23(13/14): 1549-1558.
Metolachlor is being considered for control of eastern black nightshade (Solanum ptycanthum Dun.) in cabbage (Brassica oleracea L. var. capitata), broccoli (B. oleracea L. var. Botrytis) and tomato (Lycopersicon esculentum Mill.). We have developed a rapid, sensitive method to determine metolachlor residues in these commodities to ensure its absence in the edible tissue. The crop material was extracted with methanol, the extract partitioned with hexane, then passed through a silica cartridge and analysed for metolachlor by GC/MSD in selected ion mode at m/z 161. Recovery of metolachlor from fortified plant material was greater than 84%. The method detection limit was calculated to be 0.6 ppb for tomato, 1.1 ppb for cabbage, and 4.2 ppb for broccoli. Metolachlor residues were below the detection limit in all commodities harvested from treatments which recieved 2 or 3 kg metolachlor/ha.

(350) Bowman, B. T., G. J. Wall, et al. (1994). Transport of herbicides and nutrients in surface runoff from corn cropland in southern Ontario. Canadian Journal of Soil Science 74(1): 59-66.
The risk of surface-water contamination by herbicides is greatest following application to cropland when the active ingredients are at the maximum concentration and the soil is most vulnerable to erosion following cultivation. This study determined the magnitude of surface runoff losses of herbicide and nutrients at, and subsequent to, application. The first of three weekly 10 min., 2.6 cm rainfalls were simulated on triplicated 1 m^{2} plots (a set) on which corn had been planted and the herbicide (metolachlor/atrazine, 1.5:1.0) and fertilizer (28% N at 123 kg/ha) had just been applied. Identical simulations were applied to two other adjacent plot sets (protected from rainfall) 1 and 2 wk following herbicide application. Runoff (natural, simulated) was monitored for soil, nutrient and herbicide losses. Concentrations of total phosphorus in surface runoff water and nitrate N in field-filtered samples were not significantly influenced by the time of the rainfall simulation but exceeded provincial water-quality objectives. Atrazine and metolachlor runoff losses were greatest form simulated rainfall (about 5% loss) immediately following application. Subsequent simulated rainfall usually resulted in <1% herbicide runoff losses. Herbicide concentrations in all plot runoff samples exceeded provinvial drinking water quality objectives. Since herbicide suface transport is primarily in the solution phase (not via association with soil particles), water management conservation technologies are the key to retaining these chemicals on cropland.

(351) Braverman, M. P., T. L. Lavy, et al. (1986). The degradation and bioactivity of metolachlor in the soil. Weed Science 34(3): 479-484.
In bioassays, rice (Oryza sativa L.) recovery from metolachlor injury tended to be slower in flooded rice, but was not significantly different form the recovery rate in a nonflooded rice. In soils treated with 1 ppm (w/w) metolachlor and incubated in constant-temperature chambers, the half-life of metolachlor was shorter at 40 C than at 30 C. The degradation rate of metolachlor was not significantly correlated with declining moisture potentials in the range of -30 to -80 kPa. The CO_2 evolution from metolachlor-treated soil was negatively correlated to declining moisture levels. In a field study, metolachlor, as determined by bioassay, was mobile in a Taloka silt loam soil profile. After being incorporated to 7.5 cm, it became evenly distributed in the top 15 cm of the soil profile within 18 days. Metolachlor adsorption was positively correlated with clay and organic carbon content.

(352) Saxena, A., R. Zhang, et al. (1987). Microorganisms capable of metabolizing the herbicide metolachlor. Applied and Environmental Microbiology 53(2): 390-396.
We screened several strains of microorganisms and microbial populations for their ability to mineralize or transform the herbicide metolachlor because such cultures would potentially be useful in the cleanup of contaminated sites. Although we used various inocula and enrichment culture techniques, we were not able to isolate microorganisms that could mineralize metolachlor. However, strains of Bacillus Circulans, Bacillus megaterium,

Fusarium sp., Mucor racemosus, and an actinomycete were found to transform metolachlor. Several metabolites could be determined with high-performance liquid chromatography. The tolerance of the strains to high concentrations of metolachlor was also evaluated for the usefulness of the strains for decontamination. Tolerance of the actinomycete to metolachlor concentrations over 200 ppm was low and could not be increased by doubling the sucrose concentration in the growth medium or by using a large biomass as inoculum. However, a Fusarium sp. could grow and transform metolachlor up to a concentration of 300 ppm.

(353) Bc vman, B. T. (1990). Mobility and persistence of alachlor, atrazine and metolachlor in plainfield sand, and atrazine and isazofos in honeywood silt loam, using field lysimeters. Environmental Toxicology and Chemistry 9(4): 453-461.
Mobility and persistence of commercial formulations of alachlor, metolachlor and isazofos were studied under two moisture regimes using 75 x 15 cm field lysimeters. Formulated atrazine was also applied to each lysimeter for reference purposes. Alachlor- and metolachlor-treated lysimeters were packed with Plainfield sand, while Honeywood silt loam was used to pack isazofos-treated lysimeters. Effluent was monitored for each chemical, and selected cores were sectioned (7 x 10 cm) and analyzed to determine mobility profiles and persistence at weeks 1, 2, 4, 8, 12, and 21. The 50% disappearance times (DT50) for alachlor, atrazine, isazofos and metolachlor were:,1.5, 4, 1.5, and 3 to 4 weeks, respectively. Water application during week 1, following pesticide application, created ponding on Honeywood soil cores, transporting atrazine and isazofos to a maximum 50-cm depth. While isazofos moved no further after week 1, atrazine and desethylatrazine (Des-Atr.) exhibited considerable mobility throughout the study. Ponding on Honeywood silt loam cores produced greater atrazine and Des-Atr. movement than in Plainfield sand cores. Des-Atr. production increased with soil moisture content. Relative mobilitis in Plainfield sand were: Des-Atr. >=atrazine>metolachlor>alachlor; in Honeywood s ilt loam: Des-Atr.>atrazine>isazofos.

(354) Kruger, E. L., B. Zhu, et al. (1996). Relative mobilities of atrazine, five atrazine degradates, metolachlor, and simazine in soils of Iowa. Environmental Toxicology and Chemistry 15(5): 691-695.
The relative mobilities of atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine), five atrazine degradates, metolachlor (2-chloro-N-[2-ethyl-5-methylphenyl]-N-[2-methoxy-1 methylethyl]-acetamide), and simazine (2-chloro-4,6-bis-[ethylamino]-s-triazine) were determined in both surface and subsurface soils from five locations in Iowa by soil thin-layer chromatography (STLC). Based on mobility of the compounds, four groups were identified from this study. Deethylatrazine (2-chloro-4-amino-6-isopropylamino-s-triazine) was the most mobile compound. The intermediate mobility group included atrazine, deisopropylatrazine (2-chloro-4-ethyl-amino-6-amino-s-triazine), and didealkylatrazine (2-chloro-4,6-diamino-s-triazine). The less mobile group included metolachlor and simazine, and the nearly immobile group consisted of ammeline (4,6-diamine-s-triazine-2-ol) and hydroxyatrazine (2-hydroxy-4-ethylamino-6-isopropylamino s-triazine). A clear division between the intermediate and less mobile group was not seen in all soils. Mobilities of all eight compounds in this study were negatively correlated with soil organic matter content (p less than or equal to 0.05) and positively correlated (except for didealkylatrazine) with sand content (p less than or equal to 0.05). The greatest degree of mobility for the compounds studied was seen in Fruitland (sandy) and Nashua (sandy clay loam) subsurface soils, which also had the least organic matter contents. The mobility relationship of atrazine, deethylatrazine, and deisopropylatrazine in this study (deethylatrazine greater than or equal to atrazine-deisopropylatrazine) is consistent with groundwater monitoring reports. Similar mobilities of atrazine.

(355) Koncal, J. J., S. F. Gorske, et al. (1981). Leaching of EPTC, alachlor, and metolachlor through a nursery medium as influenced by herbicide formulations. HortScience 16(6,sect.1): 757-758.

(356) Nations, B. K. and G. R. Hallberg (1992). Pesticides in Iowa precipitation. J environ qual 21(3): 456-492.
Rainfall was sampled for pesticides to assess their occurrence in precipitation and potential impacts on water resources. Three areas in Iowa were sampled; two localities were in rural settings, and a third in an urban area. Fourteen pesticides, including ten herbicides and four insecticides, were detected from October 1987 through September 1990. Atrazine, alachlor, cyanazine, and metolachlor were the most commonly detected, with one or more of these four herbicides found in almost every rainfall sample during the growing season. Concentrations of individual pesticides ranged from 0.1 micrograms L-1 to 40.0 micrograms L-1, with most detections under 1.0 micrograms L-1. Pesticide detections in rainfall began in April and ended in July or August, probably related to the timing of chemical application and greater volatilization rates during warmer weather. Samples from the urban site had detections of the same agricultural chemicals found at the rural sites, but in lesser quantities. In addition to the commonly detected herbicides, three of the four insecticides detected in rainfall were only found in urban samples. Two of these have urban as well as agricultural uses. Some variation of pesticide detections were seen at the three sampling localities, related to regional and local use patterns. Concentrations were greater at sampling sites near fields where pesticides are applied, suggesting that local volatilization and distance of transport affect the concentrations in rainfall. Pesticide concentrations were highest at the beginning of a rainfall event with concentrations becoming lower in samples taken later in the event.

(357) Gaynor, J. D., D. C. MacTavish, et al. (1995). Atrazine and metolachlor loss in surface and subsurface runoff from three tillage treatments in corn. Journal of Environmenstl Quality 24(2): 246-256.
Conservation tillage with residue management has been proposed as the most effective means to reduce soil deterioration in southwestern Ontario. Two conservation tillage treatments, ridge (RT) and zero (ZT) tillage, were compared with conventional moldboard plow (CT) tillage from 1987 to 1990 for atrazine [6-chloro-N-ethyl-N'-(1-methyethyl)-1,3,5-triazine 2,4-diamine], deethylatrazine [6-chloro-N'-(1-methylethyl)-1,3,5-triazine 2,4-diamine], and metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N (2-methoxy-1-methylethyl)acetamide] loss in surface runoff and tile discharge. Twenty-five to 44% of the annual rainfall resulted in total field runoff (surface runoff or tile discharge). Conservation tillage increased surface runoff 42% and decreased tile discharge 15% compared with conventional tillage, but total field runoff was the same from all treatments. Runoff events shortly after herbicide application produced the greatest herbicide concentrations and losses in both surface runoff and subsurface drainage. Averaged over years, herbicide concentration in surface runoff and tile discharge was, respectively, 1.3 and 1.8 times greater from conservation than conventional tillage. Conservation tillage altered the source of herbicide loss compared with conventional tillage, but environmental factors after herbicide application were more important in determining total herbicide loss than tillage. Deethylatrazine was found in both surface runoff and tile drainage and accounted for 10 to 27% of combined atrazine and deethylatrazine loss.

(358) Bowman, B. T. (1988). Mobility and persistence of

metolachlor and aldicarb in field lysimeters. Journal of Environmental Quality 17(4): 689-694.
The mobility and persistence of metolachlor [2-chloro-N-(2-ethyl-6- methylphenyl)-N-(2-methoxy-1-methyl)acetamide], a herbicide, and aldicarb [2,methyl-2-(methylthio)propanaldehyde O-(methylcarbamoyl)oxime], an insecticide, were studied using field lysimeters containing 15 cm (diam.) by 70 cm (length) cores of Plainfield sand (mixed, mesic Typic Udipsamments). One-half of the cores received only rainfall, while the remainder received rainfall plus simulated 50.8-mm rainfalls on the second and eighth days after treatment, followed by simulated irrigation for the duration of the study. Metolachlor exhibited limited mobility, except in the supplementary watering treatment, in which there was rapid transport of some herbicide 40 cm down the core, with accompanying traces in the effluent. Metolachlor half-life was in the 3- to 4-wk range. Aldicarb rapidly converted to its sulfoxide [2-methyl-2-(methyl)sulfinyl]propanal O-(methylamino)carbonyl oxime] and sulfone [2-methyl-2-(methylsulfonyl)propanal O-(methylamino)carbonyl oxime] (50% in 3-5 d). Under normal rainfall, about 9% of the applied aldicarb leached out of the soil cores as sulfoxide or sulfone. In cores ?receiving supplementary watering, up to 64% of applied aldicarb appeared in the effluent principally as sulfoxide or sulfone.

(359) Buttle, J. M. (1990). Metolachlor transport in surface runoff. J environ qual 19(3): 531-538.
In 1987 metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide] was applied to a 5.5-ha corn field in southern Ontario, Canada, in two separate areas--as a preemergence surface spray with cross-contour plowing and as a preplant incorporated treatment with contour plowing. The application rate for both treatments was 2.64 kg a.i. ha-1. Metolachlor concentrations in soils and in the dissolved and adsorbed phases in runoff from natural rainstorms were monitored throughout the growing season. Persistence in soils decreased exponentially after application, although there was evidence of temporary accumulation of metolachlor in footslope areas. Dissolved concentrations in runoff decreased with time, while temporal trends in adsorbed concentrations reflected changes in metolachlor persistence in soils. Average ratios of adsorbed to dissolved herbicide concentrations ranged from 7 to 57, and were dependent upon hydrological and pedologic conditions within the treatments. Sediment carried between 9 to 58% of the total metolachlor yield from runoff plots during individual storms, and 20 to 46% of the total yield over the monitoring period. Herbicide incorporation and contour plowing led to significant reductions in dissolved and adsorbed concentrations, and in total metolachlor loss in runoff, relative to application as a preemergence spray with cross-contour plowing. Incorporation was associated with an increase in the relative importance of sediment in metolachlor transport. Variations in herbicide losses and the relative importance of transport vectors within a given treatment were linked to local hydrological processes.

(360) Levanon, D., E. E. Codling, et al. (1993). Mobility of agrochemicals through soil from two tillage systems. J environ qual 22(1): 155-161.
The fate of agrochemicals is often greatly affected by the surface-soil conditions in the field. This study was conducted to characterize the impact of two contrasting tillage systems on the movement of agrochemicals in soil. The two tillage systems were plow-tillage (PT) and no-tillage (NT) for corn (Zea mays L.) production. The study included incubation and leaching of undisturbed soil columns and disturbed soil samples from 16-yr plots subject to the two tillage regimes. The agrochemicals used in the study were NH4NO3, atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine-2,4 diamine), carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate), diazinon (0,0-diethyl-O-(6-methyl- 2(1 -methethyl)-4-pyramidnyl phosphorothioate), and metolachlor (2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-metoxy-1-methylethyl) acetamide). The results of this study show greater ponded flow movement of all agrochemicals in soils under PT vs. NT conditions. Strong evidence was found for preferential flow through the soil, with the chemicals by-passing much of the soil-matrix under recently plowed soils as well as NT soils. Nitrate leaching was significantly greater under PT than NT, apparently due to greater mineralizing activity of the PT soil compared with the NT soil. The pesticide movement also tended to be greater under PT than NT. Caution should be exercised in generalizing to field conditions, but these data suggest that there can be greater leaching losses of surface-applied agrochemicals to groundwater under PT than under NT.

(361) Smith, C. N. and R. S. Parrish A field study to evaluate leaching of aldicarb, metolachlor, and bromide in a sandy loam soil. J environ qual 22(3): 562-577.
Transport and transformation of pesticides used in agricultural situations are subject to vailability from several sources that are impossible to simulate in laboratory settings. This study was conducted to characterize pesticide leaching behavior under conventional croping conditions and to determine the impacts of related sources of vailability. An agricultural field site (Ardilla fine sandy loam, Clarendon loamy sand, Tifton loamy sand, and Lucy loamy sand) located within the Dougherty Plain region of southwest Georgia was used to study pesticide movement in unsaturated and saturated soil zones from 1984 through 1988. A granular formulation of aldicarb [2-methyl-2 - (methylthio) propionaldehyde O-(methylcarbamoyl) oxime], an emulsifiable concentrate of metolachlor [2-chloro-N-(2-ethyl-6-methyl-phenyl)-N-(2-methoxy-1-methyl ethyl) acetamide], and a bromide (Br-) tracer were applied on peanut (Arachis hypogea L.) crops under modified conventional tillage practices. Postapplication vertical movement was monitored for periods of up to 111 d for pesticides and 1307 d for Br-. Application distributions for aldicarb showed measured coefficients of variation ranging from 42 to 72, and for metolachlor from 23 to 44. Spatial variability analyses indicated the existence of small-scale correlation for both pesticides upon initial application, and some large-scale trending was observed for metolachlor. Field-based transformation rates of aldicarb were up to three times higher than laboratory-based values. There was no evidence of migration of any of the pesticides into the saturated zone during the study, although Br- was observed at less than 1 mg kg(-1) in well-water samples. Aldicarb degraded almost completely within d each year, and.

(362) Zheng, S. Q., J. F. Cooper, et al. (1993). Distribution and dissipation of metolachlor in soil columns. Journal of Environmental Science and Health 28(6): 641-653.
Distribution and dissipation of metolachlor in a soil of Montpellier were evaluated in laboratory conditions for 8 weeks using 100 cm PVC pipes. The half-lives of metolachlor varied from 31 to 54 days according to the application dose (1.2, 4.5, and 9 kg ai/ha respectively). The rate of herbicide migration increased with stronger dose. Adsorption and desorption of metolachlor were studied in the same soil at three different depths. Soil Freundlich adsorption coefficients (K_{fo}) were 1.0, 0.7, and 0.6 for 0 to 10, 10 to 50 and 50 to 95 cm depths respectively. Desroption coefficients (K_{fd}) varied more slighly (3.6 - 3.9). Ratio soil quantity/water volume may influence adsorption parameters.

(363) Dureja, P. and S. Walia (1989). Photodecomposition of pendimethalin. Pesticide Science 25(2): 105-114.
The photodecomposition of pendimetholin in solution, as a thin film, and on soil surfaces under ultraviolet light and sunlight was

investigated. Irradiation of pendimethalin in methanol yielded, in addition to the minor dealkylated product, the major products 2-amino-6-nitro-N-(1-ethylpropyl)-3,4-xylidine and 2-nitroso-6-nitro-3,4-xylidine. Pendimethalin was found to degrade rapidly through reductive cyclisation of a nitro group and an adjacent N-ethylpropyl group to give a cyclised benzimidazole product. The photodecomposition of pendimethalin involves oxidative dealkylation, nitro reduction and cyclisation.

(364) Barua, A. S., J. Saha, et al. (1990). Degradation of pendimethalin by soil fungi. Pesticide Science 29(4): 419-425.
Several soil fungi, Aspergillus flavus, Aspergillus terreus, Fusarium solani, Fusarium oxysporum, Penicillium citrinum and Penicillium simplicissimumeffectively degrade pendimethalin supplied as sole carbon source in mineral solution. Degradation of pendimethalin by F. solani resulted in the isolation and identification of N-propyl-3-methyl-4-hydroxy-2,6-dinitroaniline, N-(1-ethylpropyl)-2-amino-6-nitro-3,4-xylindine and 2,6-dinitro-3,4-xylidine. The partial pathways involved in the degradation of pendimethalin have also been proposed.

(365) Zimdahl, R. L., P. Catizone, et al. (1984). Degradation of pendimethalin in soil [Weed control]. Weed Science 32(3): 408-412.
Pendimethalin degradation in three soils did not follow first-order kinetics but could be described by a quadratic model. Degradation increased as soil temperature increased in the order 10, 20, 35, and 30 C. The rate was the same as 75 and 100% field capacity but slower at 50%. At the same temperature and soil moisture the influence of soil type was small. Based on chemical analysis of soil from field and laboratory studies, the half-life was approximately 47 days. Based on biological analyses of soil, the half-life was 78 to 111 days.

(366) Pedersen, H. J., P. Kudsk, et al. (1995). Adsorption and ED50 values of five soil-applied herbicides. Pestic Science 44(2): 131-136.
The soil partition coefficients (Kd values) and ED50 values of carbetamide, isoproturon, propyzamide, trifluralin and pendimethalin were determined on various soil types. Adsorption increased in the order carbetamide < isoproturon < propyzamide < trifluralin < pendimethalin, whereas the influence of soil type on herbicide efficacy increased in the order isoproturon < carbetamide < pendimethalin < trifluralin < propyzamide. The relationship between adsorption and ED50 values of the herbicides was examined by estimating the herbicide concentration in soil water solution. Adsorption and ED50 values on common Danish soil types (0.6% carbon and 12% day to 2.3% carbon and 4.4% clay) differed by factors of up to three and four, respectively, indicating a possibility of adjusting the herbicide dose according to soil factors.

(367) Kuhns, L. J. (1992). Efficacy and phytotoxicity of three landscape herbicides with and without a light mulch. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 46: 85-89.
Seedling geranium, Discovery Orange marigold, White Madness petunia, Pulcino Mix zinnia, purple wintercreeper euonymus, English ivy, vinca, Meyer lilac, and Burkwood viburnum were planted on May 20-21, 1991. On May 22-23 the following treatments were established: control, oxadiazon at 4.4 kg/ha, simazine + metolachlor at 1.1 + 3.3 kg/ha, and oxyfluorfen + oryzalin at 2.2 + 1.1 kg/ha; each on bare soil or lightly covered with a mulch. The mulch was coarsely ground wood chips spread to a depth of 1.5 cm or less. The percent weed control provided by each treatment was rated on July 4 and September 6, 1991. All plots were handweeded by July 9 to minimize the effects of weed competition of plant growth. All flower plants were harvested and weighed Oct. 9-10. On July 4 both control plots were covered with weeds, but the mulched control appeared to have a higher density of weeds. It was obvious that the thin layer of mulch was not inhibiting weed growth, but may in fact have enhanced it. The herbicide treatments without mulch provided total weed control. In plots with mulch, the oxyfluorfen + oryzalin combination provided almost total weed control, while the oxadiazon and the simazine + metolachlor provided 90% control. Applying a light layer of mulch reduced the effectiveness of the herbicides. On September 6 the herbicide treatments without mulch still provided close to total weed control. With mulch, the oxyfluorfen +oryzalin combination provided over 80% weed control. The oxadiazon or simazine +metolachlor combination provided close to 70% weed control. There was no difference in crop plant size between the controls with and without mulch. Geranium, marigold, petunia, and viburnum plants in the simazine + metolachlor plots without mulch were smaller than those in the plots with mulch. The geranium, marigold, petunia, zinnia, lilac, viburnum, and vinca were smaller in the oxadiazon treated plots without mulch than in those with mulch. The euonymus and ivy are apparently resistant to oxadiazon activity because they grew equally well in the mulched and unmulched plots. In the oxyfluorfen + oryzalin treated plots, the geranium, marigold, petunia, zinnia, and vinca were smaller in the plots without mulch than in those with mulch. The growth of none of the other woody plants in the unmulched plots was reduced by this treatment.

(368) Hood, L. R. and J. E. Klett (1992). Preemergent weed control in container-grown herbaceous and woody plants. Journal of Environmental Horticulture 10(1): 8-11.
Six herbicides were applied to four woody and two herbaceous plant species to evaluate weed control effectiveness, effect on plant growth and phytotoxicity level. Surflan at 2.3, 4.5, 6.8 kg ai/ha, Devrinol at 5.5, 9.1, 13.6 kg ai/ha, and Dual, Rout, and Snapshot at 3.4, 6.8, 10.2 kg ai/ha were applied to container-grown green ash, and white birch. Additionally, Surflan at 2.3, 4.5 kg ai/ha, Ronstar and Devrinol at 5.52, 9.1 kg ai/ha, Dual and Rout at 3.4, 6.8 kg ai/ha were applied to container-grown Tatarian maple, virginal mock orange, daylily, and clematis. Weed seed sown in both experiments included: yellow foxtail, barnyardgrass, annual bluegrass, common chickweed, shepardspurse and common groundel.
Plants were grown in 2.5 L black plastic containers in a medium of sandy loam topsoil, plaster sand and sphagnum peat (1:1:1 by volume). Good weed control occured in most cases with all herbicides except Devrinol and Dual. No visual foliage injury occurred in any treatment but significant growth reduction was observed with the 10.2 kg ai/ha rate of Snapshot with white birch. Growth reduction of tartarian maple was also observed with 6.8 kg ai/ha rate of Dual and 4.25 kg ai/ha rate of Surflan.

(369) Rice, R. P. (1992). Section III Ornamental Herbicide Guide. Nursery and landscape weed control manual by Robert P. Rice, Jr. Rev. and updated ed. Fresno, Thomson Publications: 129-283.

(370) Neal, J. C. and A. F. Senesac (1991). Preemergent herbicide safety in container-grown ornamental grasses. HortScience 26(2): 157-159.
Preemergent herbicide phytotoxicity was evaluated for six species of container-grown ornamental grasses: beach grass (Ammophila breviligulata Fern.), pampas grass [Cortaderia selloana (Schult. & Schult. f.) Asch. & Graebn.], tufted hair grass [Deschampsia caespitosa (L.) Beauvois.], blue fescue [Festuca ovina cv. glauca (Lam.) W.D.J. Koch], fountain grass [Pennisetum setaceum (Forssk.) Chiov.], and ribbon grass (Phalaris arundinacea cv.

picta L.). Herbicides included isoxaben, metolachlor, MON 15151, napropamide, oryzalin, oxadiazon, pendimethalin, prodiamine, and trifluralin; the granular combination products of benefin plus trifluralin; and oxyfluorfen plus pendimethalin. Metolachlor, granular or spray, and oryzalin severely injured all species tested, except beachgrass, which was not injured by metolachlor granule. Napropamide injured pampas grass, fountain grass, blue fescue, and tufted hair grass, but was safe on ribbon grass and beach grass. Pendimethalin, prodiamine, trifluralin, MON 15151, isoxaben, oxyfluorfen plus pendimethalin, and benefin plus trifluralin were safe on all six species.

(371) Skroch, W. A., C. J. Catanzaro, et al. (1994). Preemergence herbicide evaluations on selected spring and summer flowering bulbs and perennials. Journal of Environmental Horticulture 12(2): 80-82.
Nine species of field-grown flowering bulbs and perennials were screened for tolerance to the preemergence herbicide products Dacthal (DCPA), Gallery (isoxaben), Pennant (metolachlor), PRE-M (pendimethalin), Stakeout (dithiopyr), Derby (metolachlor + simazine) and Snapshot (isoxaben + oryzalin). Herbicides were applied at recommended rates three to five times over two to three years. No detrimental effects on growth, development or flowering were observed. Most products controlled large crabgrass, horseweed and prostrate spurge. However, control of crabgrass and spurge was poor with Gallery at 0.84 kg ai/ha, and control of horseweed and spurge was poor with Dacthal.

(372) Derr, J. F. (1994). Weed control in container-grown herbaceous perennials. HortScience 29(2): 95-97.
Tolerance of transplanted black-eyed Susan (Rudbeckia hirta var. pulcherrima (Farw.), lanceleaf coreopsis (Coreopsis lanceolata L.), shasta daisy (Chrysanthemum X superbum Bergmans ex. J. Ingram), purple coneflower [Echinacea purpurea (L.) Moench.], and blanket flower (Gaillardia aristata Pursh) to preemergence herbicides was evaluated in container trials. Herbicides were applied at the maximum use rate and twice the maximum use rate. Dithiopyr, pendimethalin, and prodiamine provided excellent control of spotted spurge (Euphorbia maculata L.) and yellow woodsorrel (Oxalis stricta L.) with little injury to the five herbaceous perennials. DCPA, oxadiazon, and metolachlor were tolerated by all treated species, but these chemicals provided lower control of one or both weed species. Oryzalin, isoxaben + trifluralin, and napropamide caused unacceptable injury and shoot fresh-weight reductions in some of the perennials at one or both application rates.

(373) Frank, J. R. and J. A. King (1979). Metolachlor and Alachlor for Weed Control in Establishing Woody Nursery Stock. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 33: 228-231.
A field experiment was conducted to test the effectiveness of metolachlor and alachlor alone or in combination with simazine for weed control in the establishment of four species of woody nursery stock. Metolachlor and alachlor alone gave short-term control of annual weeds. Combinations with simazine lengthened the period of effective weed control. Follow-up treatments of glyphosate and paraquat were applied to control the perennial weed population. Glyphosate was more effective than paraquat in controlling weeds over a 45-day evaluation period.

(374) Gaynor, J. D., A. S. Hamill, et al. (1993). Efficacy, fruit residues, and soil dissipation of the herbicide metolachlor in processing tomato. Journal of the American Society of Horticulture Science 118(1): 68-72.
Metolachlor was evaluated for annual grass and eastern black nightshade (Solanum ptycanthum Dun.) control in processing tomato (Lycopersicon esculentum Mill.). Metolachlor applied preplant incorporated provided excellent (> 88%) control of annual grasses and eastern black nightshade. The metolachlor, metribuzin plus trifluralin tank mix applied preplant and incorporated into the soil provided better annual grass and eastern black nightshade control than the metolachlor plus metribuzin tank mix in two of three years. Nonincorporated and posttransplant treatments of metolachlor provided good annual grass control but failed to control eastern black nightshade. Tomato yield in all herbicide treatments was similar to that from hand weeded controls. Metolachlor dissipated from the soil throughout the growing season so that at the time of harvest < 10% of that applied was recovered. Metolachlor residues in the fruit were hydrolyzed to deacylated (CGA 37913) or hydrolyzed conjugated (CGA 49751) metolachlor metabolites. Analyses of extracts from treated fruits were found to be less than the detection limit of 50 ppb in the whole fruit harvested from selected metolachlor treatments.

(375) Wilson, H. P., T. E. Hines, et al. (1988). Efficacy comparisons of alachlor and metolachlor formulations in the field. Weed Technology 2(1): 24-27.
In field studies conducted in 1984, 1985, and 1986, annual grass control by a microencapsulated (ME) formulation of alachlor generally was greater than that by the emulsifiable concentrate (EC) in no-till and was comparable to EC-alachlor in conventionally tilled corn and soybeans. In 1986, ME-metolachlor controlled annual grass similar to EC-metolachlor. In greenhouse studies, shoot height and fresh weight of barnyardgrass sown in pots and treated with ME-alachlor was significantly greater than that treated with EC-alachlor. Soybean straw on the soil surface did not affect the differences between alachlor formulations in the greenhouse.

(376) Hall, M. (1986). Post-emergence weed control in a radiata pine nursery with four selective herbicides. Australian Forestry 49(3): 155-159.
Azioprotryne, a mixture of propazine and chlorthal, fluazifop-butyl and haloxyfop-ethoxyetheyl were each applied to radiata pine seedbeds two weeks after pine emergence, while the latter two herbicides were also applied ten weeks after emergence. In weed-free conditions (created by a pre-emergence application of propazine plus chlorthal and regular hand-weeding), pine seedling survival and top dry weight were not significantly affected by any of the post-emergence herbicide treatments. However, there was some evidence of pine damage with aziprotryne at 6.0 kg/ha ai. The propazine plus chlorthal mixture failed to reduce weed dry weights. Aziprotryne at 3.0 and 6.0 kg/ha ai was active on broadleaf weeds, in this case mainly wireweed, but at a selective rate, (3.0 kg/ha ai), aziprotryne did not significantly reduce grass dry weight or numbers. Fluazifop-butyl at 0.85 and 1.7 kg/ha ae and haloxyfop-ethoxyethyl at 0.42 and 0.84 kg/ha ae provided excellent control of small grass weeds when applied two weeks after pine emergence, but failed to control more established grasses when applied at ten weeks. Neither fluazifop-butyl nor haloxyfop-ethoxyethyl had any effect on broadleaf weeds. It is suggested that a mixture of one of these chemicals with a suitable rate of aziprotryne may provide an effective broad-spectrum post-emergence weedicide treatment for radiata pine seed-beds.

(377) Rice, R. P., Jr., G. Lewis, et al. (1985). Potential of Fusilade, Poast and CGA 82725 for control of weedy grasses in woody nursery crops and groundcovers. Journal of Environmental Horticulture 3(1): 28-32.
To assess crop safety, Fusilade (fluazifop-butyl), Poast (sethoxydim) and DGA 82725 were applied to nursery crops and groundcovers. Of the species tested, injury was minimal except of

Juniperus horizontalis 'Bar Harbor' with both Fusilade and CGA 82725 and on Carpobrotus edulis with Fusilade where serious injury occurred. In field tests, both Fusilade and Poast controlled established bermudagrass in both established and newly planted groundcovers and dichondra without injury at 1.12 and 2.24 kg/ha.

(378) Stamps, R. H. and C. A. Neal (1990). Evaluation of dinitroaniline herbicides for weed control in container landscape plant production. Journal of Environmental Horticulture 8(2): 52-57.
Five formulations of three dinitroaniline (DNA) herbicides [Surflan (oryzalin); Pre-M, Southern Weedgrass Control (pendimethalin); and Barricade (prodiamine)] were applied at 4.48 kg ai/ha every four months to container-grown landscape plants. These treatments were compared with untreated and weed-free controls, as well as the combination herbicides Rout and Ornamental Herbicide 2 composed of oryzalin or pendimethalin, respectively, (1.12 kg ai/ha) with Goal (oxyfluorfen) (2.24 kg ai/ha). The combination herbicides caused the greatest amount of acute phytotoxicity, severely damaging Hemerocallis hybrid 'Aztec Gold' and Liriope muscari 'Big Blue'. Water dispersable granular formulations of Pre-M and Barricade were phytotoxic to Photinia x fraseri while the granular formulations were not. Surflan caused the greatest reduction in crop growth and was the only treatment that reduced survivial. Surflan and OH-2 inhibited daylily flowering 98% and 65% respectively. Hairy bittercress, spotted spurge, and yerba-de-tago control generally was the best with Barricade and treatments containg Goal. All herbicides, except Surflan, reduced weed biomass after two herbicide applications. All herbicides provided significant weed control after three applications.

(379) Thetford, M. and C. H. Gilliam (1991). Herbicide use in propagation: effects on rooting and root growth of stem cuttings. Journal of Environmental Horticulture 9(1): 21-33.
Two experiments were conducted to determine the effects of several preemergence applied herbicides on rooting, root quality and subsequent root growth of selected woody cuttings. In the first experiment Ilex x attenuata Ashe 'Fosteri' rooting percentage primary root numbers and root ratings were suppressed with Surflan (oryzalin). In the second experiment, the long-term effects of herbicide use in propagation were monitored for 13 months after potting. Suppression of one or more rooting variables occurred after cuttings were placed in propagation. Thirteen months later, Surflan treated boxwood exhibited root and shoot growth suppression while 'Compacta' holly exhibited suppressed root growth.

(380) Skimina, C. A. (1984). Phytotoxicity and efficacy of oxyflourfen in container crop production [Herbicides]. Proceedings of the California Weed Conference(36th): 145-151.

(381) Corell, T. (1979). Nursery Weed Control on Long Island. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 33: 240-241.

(382) Derr, J. F. (1994). Innovative herbicide application methods and their potential for use in the nursery and landscape industries. HortTechnology 4(4): 345-350.
Chemical weed control is an important weed management option in nursery crop production and landscape maintenance. Improved methods of herbicide delivery can increase efficacy of chemical control and minimize off-site movement, applicator exposure, and incorrect herbicide application. Certain innovative technologies show potential for addressing these issues in the nursery industry. Slow-release herbicide tablets have shown promise in container production. Horticultural collars, treated paper, and treated mulch are potential ways of applying herbicides in container crop production and/or landscape maintenance. Horticultural collars contain herbicides between two layers of a carrier such as a landscape fabric. A rapidly degradable paper can be pretreated with an herbicide for a precise application rate. Mulch can be treated with a herbicide prior to use in the landscape for improved weed control. Herbicides applied through the clip-cut pruning system could control weeds selectively in nurseries and landscapes. Each of these methods may address one or more concerns about off-site movement, calibration, and applicator exposure to pesticides.

(383) Smith, E. M. and S. A. Treaster (1991). The effect of slow-release herbicide tablets on container-grown woody and herbaceous landscape crops. Ornamental Plants. A Summary of Research. Ohio State University(137): 1-5.
A study was conducted to evaluate the effectiveness of slow-release herbicide tablets of herbaceous and woody container-grown nursery stock. The tablets contained oxyfluorfen (Goal) at 0.5 lbs ai/A, metolachlor at 2.0 lbs ai/A and the surfactant Triton X-100 at 2% by volume. At 10 weeks, weed control was acceptable at 1 tablet/1 gal. container, 2 tablets/2 gal. container, 3 tablets/3gal. container, and 4 tablets/5 gal. container. One additional tablet/container increased weed control, but only slightly. Only Gold Flame spirea was injured among the seven herbaceous plants and 16 woody selections in the study. The larger tablet size, lower pressure and increased soluble herbicide (pennant) and surfactant concentrations combined to improve weed control over previous tablet evaluations.

(384) Schreiber, M. M., M. V. Hickman, et al. (1994). Efficacy of starch-encapsulated formulations of atrazine containing two or three herbicides in same granule. Weed Technology 8(1): 105-113.
Field experiments were conducted in 1990, 1991, and 1992 to evaluate and compare the efficacy of commercial herbicide formulations with starch encapsulated granules that contain one, two, or three herbicides. Atrazine in combination with alachlor or metolachlor composed the two-component granules and the addition of dicamba to both composed the three-component granules. All starch-encapsulated formulations were produced by twin screw extrusion technology and evaluated in two granule sizes, 1.4 to 0.5 mm(14 to 20 mesh) and 0.85 to 0.43 mm (20 to 40 mesh). Active ingredient rates applied were selected for the existing soil conditions and combination granules contained active ingredients proportional to premixed commercial formulations available or suggested for tank mixes. Evaluations were performed under conventional, chisel, and no-tillage systems. PRE and PPI applications of starch encapsulated two-component (atrazine-alachlor) in 1990 controlled giant foxtail (except at the low rate with large granule size), redroot pigweed, and common lambsquarters excellently but control of velvetleaf was fair to poor. Smaller-sized granules were generally more effective for controlling weeds than the larger-sized granules. In 1991, starch-encapsulated two-component (atrazine-metolachlor) granules applied both PRE and PPI in conventional, chisel, and no-till systems gave results similar to 1990 with the small granules more effective on velvetleaf. The addition of dicamba in the granule to form three-component starch-encapsulated granules in 1992 resulted in control of velvetleaf, ivyleaf morningglory, and jimsonweed statistically equal to commercial formulations except in one case of no-till corn. In our experiments, herbicide formulations (granular vs. commercial) had no significant effect on corn yield in 28 out of 31 treatments. These data indicate that if the experimental three-component starch-encapsulated formulations of corn herbicides used in these studies were optimized they could become as efficacious as commercial formulations presently on the market. This is the first report of research containing data on two- and three- component starch-

encapsulated granular formulations.

(385) Buhler, D. D., M. M. Schreiber, et al. (1994). Weed control with starch-encapsulated alachlor, metolachlor, and atrazine. Weed technol 8(2): 277-284.
Field research was conducted at Rosemount, MN in 1990 and 1991 to determine the effect of starch encapsulation on weed control in corn with alachlor, metolachlor, and atrazine under two weed densities. At low weed densities (122 total plants/m^2), giant foxtail and Pennsylvania smartweed control were not different with full rates of herbicide applied in starch encapsulated or commercial formulations. Velvetleaf control was less with starch-encapsulated than commercial formulations regardless of velvetleaf density. At high giant foxtail densities (740 plants/m^2), control was not affected by formulation with full rates of alachlor plus atrazine. However, giant foxtail control was less with starch-encapsulated formulations than commercial formulations with 75% rates of alachlor plus atrazine and both 75 and 100% rates of metolachlor plus atrazine. At low weed densities, corn yield was not different with any treatment, except starch-encapsulated metolachlor plus atrazine at 75% rates, compared to the weed-free control. Alachlor plus atrazine at full rates was the only starch-encapsulated treatment to result in corn yield not different from the weed-free conrol at high weed densities. Conversely, all commercial formulation treatments resulted in corn yields not different from the weed-free conrol at high weed densities.

(386) Gorski, S. F., S. Reiners, et al. (1989). Release rate of three herbicides from controlled-release tablets. Weed Technology 3(2): 349-352.
Six, 9 and 12 mm diam. dicalcium phosphate tablets were evaluated for their release of acetochlor, metolachlor, and metribuzin. Greenhouse bioassays with Italian ryegrass demonstrated that herbicides from the smaller tablets did not control grass as long as from the larger tablets. Italian ryegrass was controlled within a 5- to 7- cm diam. circle around the 12-mm diam. tablet and a 5-cm diam circle around the 6-mm diam tablet. All tested herbicides responded in a similar fashion. Six-mm diam tablets released metolachlor for 11 weeks, while the 12-mm tablet was active for 28 weeks.

(387) Gorski, S. F. (1993). Slow-release delivery system for herbicides in container-grown stock. Weed Technology 7(4): 894-899.
Metolachlor, applied to the surface of leaching columns as dicalcium phosphate tablets, was recovered over a period of 25 d compared with 2 and 3 d for emulsifiable concentrate and granular formulations, respectively. In similar studies, approximately 27% of napropamide was recovered from tablets, during the same period. Adding an adjuvant to the napropamide tablet mixture increased the recovery rate to 55%. Tablet hardness and size had little effect on the release rate of napropamide. Tablets containing 4% ai napropamide released greater amounts of herbicide at a single collection period than did tablets containing 1% ai. Adding an adjuvant to the napropamide tablet mixture significantly improved Italian ryegrass control in the area adjocent to herbicide placement.

(388) Ruizzo, M. A., E. M. Smith, et al. (1983). Area of weed control from a single herbicide tablet in nursery containers. Research Circular: Ohio Agriculture Research Development Center(274): 25-27.
A 35.6 lb ai/A of Dual (metolachlor) was incorporated into two slow release tablet formulations and evaluated for specific area of weed control in nursery containers. Dual tablet treatments significantly reduces weed density in the area (5.5 to 7.0 inch diameter circles) surrounding a single herbicide tablet. The plaster of paris of dicalcium phosphate tablet formulations did not significantly differ in the suppression of weed germination in nursery containers.

(389) Horowitz, M., E. M. Smith, et al. (1990). Feasibility of adding surfactants to slow-release herbicide tablets for container-grown landscape plants. Journal of Environmental Horticulture 8(1): 36-41.
Slow-release tablets made of dicalcium phosphate containing a herbicide and a surfactant were evaluated for weed growth. The addition of 1-2% surfactant to herbicides having a very low water solubility, such as Gallery (isoxaben), Surflan (oryzalin), Ronstar (oxadiazon), and Goal (oxyfluorfen), and for comparison, to Dual (metolachlor), markedly enhanced the release of herbicide and enlarged the area of weed inhibition. The surfactants that produced the best results were Triton X-100 and X-77. Tablets placed on the surface of containers filled with Metro Mix 350 or a pine bark-peat moss-sand medium, under intermittent mist in the greenhouse, or under sprinklers outdoors, produced up to 15 cm diameter circular areas of weed control, around a single tablet. Initial release of herbicide from tablets was rapid upon exposure to moisture and the area of activity became close to maximum within a few days after placing the tablet on the soil surface. Tablets placed on surface produced larger areas of activity than when buried. The tablets retained their shape after 3 months of outdoor exposure.

(390) Smith, E. M. and S. A. Treaster (1988). Follow-up evaluation of cyanazine, terbacil and metolachlor slow-release herbicide tablets on woody landscape crops. Special Circular: Ohio Agricultural Research Development Centre(115): 1-2.
As a follow-up to 1986 studies, slow-release herbicide tablets were evaluated on container-grown Cotoneaster dammeri 'Royal Beauty', Forsythia intermedia 'Spring Glory', and Rhododendron obtusum 'Hershey Red'. Weed control from all treatments through 10 weeks of observations was acceptable. Metolachlor was noninjurious to all test species. Cyanazine at 5 and 10 kg/ha was severely phytotoxic to cotoneaster and slightly injurious to azalea. Cyanazine caused no damage to forsythia. Terbacil at 2.5 kg/ha seriously injured cotoneaster and azalea. The 5.0 rate kg/ha of terbacil was injurious to all three species. There was definitely a species response to the herbicides. Azalea and forsythia were tolerant of metolachlor and cyanazine, while cotoneaster was resistant to metolachlor. Overall these results were similar to results from 1986 studies with similar herbicides at lower rates on the same plant species.

(391) Bing, A. and C. F. Scheer (1971). The use of treated fiberglass disks for weed control on nursery containers. Northeastern Weed Control Conference Proceedings(26).
The treatment of fibreglass disks used as a mulch with alachlor plus simazine or diphenamid plus simazine gave control of liverworts (Marchantia) but only temporary control of other weeds.

(392) Smith, E. M. and S. A. Treaster (1990). Increasing efficiency of slow-release herbicide tablets. Special Circular Ohio Agricultural Research Development Center(135): 40-44.
A series of greenhouse studies were conducted to study the release of relatively insolubie herbicides from slow-release herbicide tablets. The most effective of nine surfactants was Triton X-100 at 1 percent. Highly soluble Dual at 530 ppm was selected to combine with nearly insoluble Goal at 0.1 ppm from 9 herbicide or herbicide combinations. These tablets containing Triton A-100, Dual at 5.0 lb aia and Goal at 0.5 lb aia were then applied to 10 container grown landscape species and cultivars. There was no

indication of phytotoxicity on eight of 10 plant selections for eight weeks. Weed control was acceptable for 2 tablets/container for eight weeks, 2 and 4 tablets for eight-plus weeks.

(393) Appleton, B. L. and J. F. Derr (1990). Use of geotextile disks for container weed control. HortScience 25(6): 666-668.
Disks of several geotextiles, paper, fiberglass, and black polyethylene were compared with the herbicides oxyfluorfen plus pendimethalin, oxadiazon, and oryzalin plus benefin for suppression of weed growth around container-grown Southwestern white pine, Chinese pistache, and 'Fashion' azalea. The greatest weed conrol was obtained with a combination geotextile-preemergence herbicide (trifluralin) disk, indicating a possible new method of container weed control. Several of the barrier materials, including heavy wrapping and compressed peatmoss papers, black polyethylene, and one spunbonded geotextile, were inferior due to degradation or weeds growing around the disk edges or center hole. No difference in crop growth was noted among the treatments.

(394) Rauch, F. D. (1970). Weed control by disc in container nursery production. Mississippi Agricultural Experiment Station Information Sheet(1117): 1-2.

(395) Ticknor, R. L. Evaluation of Ronstar and a combination of methazole and prodiamine on container-grown broad-leaved evergreen shrubs. Ornamentals Northwest Newsletter Cooperative Extension Service Oregegon State University 11(2): 10-12.

(396) Dumroese, R. K., D. L. Wenny, et al. (1991). Building a hand-held dispenser for top-dressing containers. Tree Plant Notes U S Department of Agriculture Forestry Service 42(2): 56-61.
Growers of container seedlings routinely cover seed with a layer of perlite, vermiculite, or grit to hold the seed in contact with moist medium, to prevent the seed from splashing out of the container during irrigation, and to reduce growth of algae and moss. At the University of Idaho, we have designed a hand-held dispenser for top-dressing our containers that gives us an easily applied, uniform convering. The device, which we call a "gritter", is the last step in our sowing line. We use it to top-dress about 120,000 cells per day with white grit.

(397) Walters, G. A. (1981). Manual Gravel Spreader for Covering Seeds in Containers. Tree Plant Notes U S Forestry Service 32(4): 15-16.
A manual gravel spreader that applies gravel to seedling containers precisely and efficiently has been developed. The gravel spreader can be modified so that available materials, different kinds and sizes of seed covering materials, and various types of containers can be used.

(398) Porter, W. C. and R. L. Parish (1994). Nontarget losses of granular herbicide applied to container-grown ornamentals. Paper of the American Society of Agricultural Engineers(94-1039/94-1074): 9.
Nontarget losses of granular material applied over widely spaced containers were reduced from 87% with a broadcast rotary applicator to 72-86% with a drop-type spreader to 48-75% with a drop spreader modified to band apply the material. Plant species and container spacing configuration had a significant effect on material loss. With a drop spreader, losses ranged form low of 10% with closely-spaced juniper to 86% with widelly spaced liriope. With a rim-to-rim hexagonal configuration, the losses varied from 10.2% with juniper to 19.9% with liriope. With a rim-to-rim square configuration, the losses varied from 15.1% with azalea to 31% with liriope. There were no significant differences in loss with the wide-spaced configuration.

(399) Ross, M. A. and D. J. Childs (1995). Herbicide mode-of-action summary. Weed science. Cooperative Extension Service, Perdue University(23): 8.

(400) Milbocker, D. C. and C. J. Elstrodt (1982). Using oxyflourfen, Goal, in the nursery Herbicide. Proceedings of the Southern Nurserymen's Association Research Conference: Annual Report(27th): 285-286.

(401) Fretz, T. A. (1973). Chemical control of weeds in container grown nursery stock. [Ilex crenata]. Research Bulletin, University of Georgia College of Agriculture Experimental Station(141): 1-38.

(402) Olson, E. (1986). Weed control: alternatives to herbicides. General Technical Report Rocky Mt Forestry Range Experimental Station U S Dept. of Agriculture and Foresty Service(137): 51-52.
In 1984 Federal use of herbicides was banned in Oregon and Washington. The purpose of this presentation is to outline the impact and response to the loss of herbicide useage at one USDA nursery, and to provide a brief look at the arsenal of tools and equipment used to keep unwanted vegetation at bay.

(403) Adams, D. (1990). Chemical weed control in containerized hardy ornamental nursery stock. Professional Horticulture 4(2): 70-75.

(404) Kuhns, L. J. and A. Michael (1992). The effectiveness of preemergence herbicides under, above, or without mulch. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 46: 90-95.
Herbicides are often used in combination with organic mulches in landscape planting. This study was conducted to compare the efficacy of simazine + metolachlor at 1.1 + 3.3 kg/ha, napropamide at 4.4 kg/ha, oxadiazon at 3.3 kg/ha, isoxaben at 1.1 kg/ha, oryzalin at 3.3 kg/ha, and isoxaben + oryzalin at 1.1 + 3.3 kg/ha when applied to bare soil, under an organic mulch, or on top of the mulch. Orange Appeal geranium, Carpet Red petunia, and Coriez Yellow marigold were planted into the plots to determine if the herbicide placement in relation to the mulch would affect the tolerance of the flowers ro the herbicides. In the two and eight week periods following application only 0.5 and 7.9 cm rain fell, and irrigation was not available. In addition; May, June, and July average 4.1, 2.1, and 1.7 C above normal. On June 6, 24 days after treatment (DAT) , weed cover was rated. On July 30, 78 DAT, all weeds were handpulled and counted. On July 30 the flower plants in each plot were assigned a quality rating.
Simazine + metolachlor provided better control when on bare soil or under the mulch than when on top. Napropamide under the mulch was the outstanding treatment in the study, providing almost total weed control throughout the season. The napropamide treatments on bare soil and on top of the mulch also provided very good control. Oxadiazon probided very good control when on bare soil and fair control when on top of the mulch. It provided no control when under the mulch. Isoxaben provided better than expected control of annual grasses. It was most effective when on bare soil, and moderately effective when under the mulch. Isoxaben did not provide any control when on top of the mulch. Like isoxaben, oryzalin provided very good control of annual grasses when of bare soil, fair control when under the mulch, and no control when on top of the mulch. The control of annual grasses provided by isoxaben plus oryzalin was similar to oryzalin alone on the bare soil, but better than either alone under the mulch or on top. Flower plant quality on July 30 was reduced most by weed competition, with the lowest rated plants in the controls. Overall, the flowers were less tolerant of the oxadiazon on bare soil than

any of the other treatments.

(405) Smith, E. M. (1990). Chemical weed control in commercial nursery & landscape plantings : 1990. Rev. Ohio Cooperative Extension Service. Ohio State University: 1-20.
Abstract: This guide provides information on pre-emergence and post-emergence herbicides for chemical weed control in commercial nursery and landscape plantings. Factors affecting herbicide performance, selecting, mixing, and calculating amounts of herbicides, and safety precautions are discussed. It includes a glossary, charts of woody plants, ground covers and flowers tolerant to herbicides, weeds controlled by pre-emergence herbicides, formulations for small areas, and an equivalents table.

(406) Smith, E. M. and S. A. Treaster (1992). An evaluation of Stakeout, a pre-emergence herbicide for container-grown nursery stock. Special Circular Ohio Agriculture Research Development Center(140): 14.
Stakeout, a new pre-emergence herbicide for nursery stock from the Monsanto Company is effective in controlling weeds for more than three months. Weeds controlled included lesser bittercress and oxalis both very troublesome species in container nurseries. This neew product was completely non-phytotoxic to container-grown Euonymus fortunei 'Emerald N Gold', Rhododendron 'Elsie Lee' and Weigela 'Newport Red' at 1.0, 1.5, and 2.0 lb/A.

(407) (1988). Nursery weed control : information day proceedings. Ontario Agricultural College Publication(0288): i-40.

(408) Frank, J. R. and J. A. Simon (1981). Glyphosate and paraquat effectiveness in woody nursery stock. Weed Science 29(4): 455-461.
Six species of 2- or 3- yr-old woody nursery stock were planted in the field in May 1976. Glyphosate at 2.2 or 4.5 kg/ha or paraquat at 0.6 or 1.1 kh/ha were applied one or two times as directed sprays in 1976 and one, two, or three times each season in 1977 and 1978. Three applications of glyphosate or paraquat were required to control weeds during the entire growing season. When late-season applications of glyphosate were made during 1977, residual weed control was observed during early 1978. When glyphosate was applied twice a year for 3 yr at 4.5 kg/ha, four of the previously dominant perennial weeds were controlled, including common dandelion, broadleaf dock, buckhorn plantain, and red sorrel. Three applicaions provided 100% control of seven of the eight remaining broadleaf perennials, including hedge bindweed and Canada thistle; six of seven species of broadleaf annuals, including Pennsylvania smartweed and tumble pigweed; and all of the remaining grass weeds. Crop size, crop quality, and marketability of the six ornamental species were not adversely affected by either herbicide. Two or three applicatons of glyphosate at 2.2 kg/ha or two treatments at 4.5 kg/ha increased plant size on andorra junipers. Three treatments of glyphosate at 2.2 kg/ha also increased the size of dwarf Japanese yews and two treatments at 4.5 kg/ha increases the size of boxleaf Japanese holly.

(409) Frank, J. R. and J. A. King (1979). Herbicide combinations for use in establishing and maintaining woody nursery plants. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 33: 262-263.
Field experiments were conducted during 1976, 1977, and 1978 to develop a program for full season weed control in newly planted and established woody nurseries. Early season applications of alachlor and alachlor-simazine combinations were followed by a directed spray application of glyphosate or paraquat. Treatments included alachlor as an emulsifiable concentrate or granular formulation at 3.4, 4.5 and 6.7 kg/ha. Alachlor EC at 3.4 and 4.5 kg/ha was also used in combination with simazine at 2.2 kg/ha. The alachlor-simazine combination was used alone; followed by a glyphosate treatment within 7 days at 2.2, 4.5, 5.6, 9.0 kg/ha; or paraquat at 0.56, 1.1, 2.2 kg/ha. Woody plants included for these tests were: Hick's yew, dwarf Japanese yew, boxleaf Japanese holly, Heller's Japanese holly, Kurume azalea Hershey Red, and Andorra juniper.
During 1976 all compounds were applied late in the growing season. The weed cover at 25 days was reduced 17% in plots treated with alachlor granular at 6.7 kg/ha. The alachlor-simazine combination followed by glyphosate at 4.5 or 5.6 kg/ha reduced the weed cover by 44% after 90 days.
A reduction in weed cover of 73% was observed 42 days after the 1977 application of the alachlor-simazine combination with a follow-up treatment of glyphosate at 4.5 or 9.0 kg/ha. Glyphosate alone at the same rate reduced the weed cover by 55 and 50% respectively. The reduction in weed cover at 75 days in plots treated with alachlor and simazine with a following glyphosate treatment at all rates was between 30 and 35% while no significant reduction in weed cover was observed in plots treated with glyphosate alone. At 100 days the alachlor-simazine combination with glyphosate at 4.5 kg/ha was the most effective treatment with a weed cover reduction of nearly 20%.
During 1978 the alachlor-simazine combination with glyphosate as a follow-up treatment reduced the weed cover from 85 to 90% after 10 days. The weed cover for the same plots observed after 50 days was 57 to 62% and 25 to 30% of the control after 80 days. This study indicated that an alachlor-simazine (4.5 + 2.2 kg/ha) application with glyphosate at each rate will provide significant reduction of weed cover for up to 80 days.

(410) Robinson, D. W. (1983). Weed control in nursery stock and amenity plantings. Recent Advances in Weed Research. W. W. Fletcher. Slough, Commonwealth Agricultural Bureaux: 199-226.

(411) Haramaki, C. and L. Kuhns (1981). Postemergent herbicides for weed infested nurseries. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 35.
Mature Hunnewell yews in an established sod and selected established broadleaf evergreen liners growing in a weed infested field were treated with several postemergent herbicides. Asulam had little or no effect on weed growth or yew injury. Glyphosate initially controlled the weeds but the area was invaded by other weeds. No injury was observed on the mature yews. Paraquat gave initial control of the weeds but the area was later infested with other weeds. Paraquat at 2 lb/A caused extensive injury to the yews. The area treated with glyphosate plus simazine gave good weed control. Most of the established one year old broadleaf evergreen liners were injured when either glyphosate alone or in combination with simazine were applied.

(412) Alexander, S. V. (1993). Pollution Control and Prevention at Containerized Nursery Operations. Water Science and Technology 28(3/5): 509-517.
Most plant materials marketed in the United States are produced in containers under controlled growing conditions at large (>20 ha) nurseries located in southern and pacific coast states. The nursery/greenhouse business is one of the fastest growing segments of American agriculture accounting for 11% of all crop income in 1991. Runoff and irrigation return flow from containerized nursery facilities can contain nitrogen, phosphorus, bacteria, certain pesticides, various salts, and trace metals. Because of their large size, the intensity of the growing cycle, the huge volume of water needed to produce the product, and the concentration of these nurseries in certain areas, there is the potential for diffuse pollution from these nurseries to adversely impact a number of surface and ground water systems in the southern and western

United States. Discharges from nursery/greenhouse operations are not federally regulated although some states require large facilities to obtain discharge permits. A number of larger nurseries in Texas, Oklahoma, and California have designed and installed pollution control and prevention systems that appear to be effective. This paper will provide background information about containerized plant culture and discuss the structural, vegetative, and management Best Management Practices that are in use at two different large containerized nurseries in Texas.

(413) Gilliam, C. H., W. J. foster, et al. (1989). Survey of weed control in container nursery operations. Research Report Series Alabama Agriculture Experimental Station Auburn University(6): 12-13.

(414) Schnelle, M. A. and J. C. Henderson (1991). Herbicide injury in the nursery and landscape. Oklahoma State University Extension Facts Cooperative Extension Service(6704): 4.

(415) Meade, J. A.. (1991). Managing perennial weeds in the nursery. FS Cooperative Extension Service Cook College(565): 2.

(416) Berchielli Robertson, D. L., C. H. Gilliam, et al. (1990). Competitive effects of weeds on the growth of container-grown plants. HortScience 25(1): 77-79.
A 2-year study evaluated the effects of three weed species: eclipta, prostrate spurge, and wood sorrel on growth of container-grown 'Gumpo White Sport' azalea (Rhododendron eriocarpum), R x 'Fashion', and Berberis thunbergii DC. var. atropurpurea 'Crimson Pigmy'. Competiveness among weed species as ranked from greatest to least was eclipta, prostrate spurge, and wood sorrel. Greater populations of eclipta and prostrate spurge resulted in decreased shoot dry weight of 'Fashion' and 'Gumpo White Sprot' azalea. Prostrate spurge had a similar effect on 'Crimson Pigmy' barberry in both small (3.8 l) and large (15.2 l) containers, while eclipta reducted shoot dry weight of barberry only in large containers. Wood sorrel had little effect on shoot dry weight of 'Fashion' and 'Gumpo White Sport' azalea.

(417) Carpenter, P. L. (1980). Methods of eliminating weeds from the nursery. American Nurseryman 151(11): 16, 69-72.

(418) Merwin, I. A., D. A. Rosenberger, et al. (1995). Comparing mulches, herbicides, and cultivation as orchard groundcover management systems. HortTechnology 5(2): 151-158.
Natural (hay, wood chips, recycled paper pulp) and synthetic (polypropylene film and polyester fabric) mulches were compared with mechanical tillage and residual herbicides as orchard groundcover management systems (GMSs). In two New York orchards - the Clarke farm and Hudson Valley Lab (HVL) - GMSs were applied from 1990 to 1993 in 1.8 m wide strips under newly planted apple (Malus domestica; 'Liberty', 'Empire', 'Freedom', and advanced numbered selections from the disease-resistant apple breeding program at Geneva, N.Y.) trees. GMS impacts on soil fertility, tree nutrition and growth, yields, crop value, and vole populations were evaluated. After 3 years at the Clarke orchard, extractable NO3, Mn, Fe, B and Zn concentrations were greater in soil with herbicides than synthetic mulches; soil K and P concentrations were greater with herbicides and wood chips than synthetic mulches. At the HVL orchard, topsoil NO3, K and Mg concentrations were greater with hay mulch than herbicides of other mulches; Mg, Fe, and B concentrations were lower in soil with wood chips than other GMSs. Soil organic matter content was not affected by GMS. Apple leaf N, K, Cu, and Zn concentrations were greater with herbicides, hay mulch, and polypropylene mulch than cultivation or recycled paper mulch at the GVL orchard during hot, dry Summer 1991. Despite transient differences among GMSs during the initial years, after 4 years of treatments there were no consistent GMS trends in cumulative tree growth or gross yields. The higher establishment and maintenance costs of several mulches were offset by their prolonged efficacy over successive years; crop market values from 1992 to 1994 were considerably greater for trees with polypropylene film, polyester fabric, and hay mulches than herbicides, cultivation, or other mulches, despite the use of mesh trunk guards and rodenticide bait.

(419) Bohmont, B. L. (1996). The standard pesticide user's guide. 4th ed. Chapter 5 Weeds. The standard pesticide user's guide. 4th ed. Upper Saddle River, Prentice-Hall, Inc.: 73-93.

(420) Schnelle, M. A. and J. C. Henderson (1991). Herbicide injury in the nursery and landscape. Extension Facts Cooperative Extension Service Oklahoma State University(6704): 4.

(421) Elmore, C. L., W. A. Humphrey, et al. (1979). Container nursery weed control. Leaflet, Division of Agriculture Science, University of California, Berkeley Cooperative Extension(21059): 11.

(422) Stamm, G. K. and R. A. Ashley (1981). The Effect of Glyphosate Application to Apple Suckers on Tree Growth. Proceeding of the Annual Meeting of the Northeastern Weed Science Society 35: 143.
Applications of glyphosate were made during the first week of June, July, August, September and October 1979 at 2.26 and 4.52 kg ae/ha. An application of 1.68 kg ae/ha was also make in July, August and October 1979. Treatment areas of each tree included a plot 2.5 by 3.6 m, the trunk and all sucker tissue and foliage. In all cases, the sucker leaf area treated in each plot was 10% or less of the total leaf area of the tree. Trees were evaluated in May and September, 1980 to determine the effect of glyphosate application on the number and size of suckers. Data was expressed as a percent of control. Additional observations were made in November, 1979 and April, June and August, 1980 to determine the extent of tree injury.
Treatment of suckers at any time or rate had no effect on tree growth in terms of terminal elongation or increase in tree circumference; however, differences were noted in terms of injury and percent change in sucker height and population. Sucker populations were readily reduced by all treatments when compare to a control treatment and/or a control treatment in which all suckers had been removed by clipping early in the first season. By the end of the second season some plots still showed reductions in percent population change but these changes were not significant due to the variability that existed. Sucker height was readily reduced in all treatments except the June treatments at the 2.26 and 4.52 kg ae/ha which were comparable to the unclipped control for the first season. Changes in sucker height the second season were not significant.
Treatment of trees in October at 4.25 kg ae/ha produced significant injury the following season which was characterized by dwarfed, chlorotic leaves in water sprouts and bark injury on the main trunk. Treatment of trees in June and October at a 4.25 kg ae/ha rate produced necrotic flakes of bark in some trees bur such injury was not serious.
Another experiment indicated that when 25% of the total leaf area of an apple tree exists as suckers and are treated with glyphosate at 2.26 or 4.25 kg ae/ha significant injury and reductions in terminal elongation and increase in tree circumference occurred the following season. Treatment of sucker leaf area which constituted 15% of the total tree leaf area at 4.25 kg ae/ha produced less injury and had no effect on terminal elongation or increase in tree circumference.
In general, both experiments indicated that sucker treatments with

glyphosate at standard herbicidal rates are safe when the treatment area is confined to sucker foliage which constitutes less than 25% of the total tree leaf area. Glyphosate appears to show a potential as a sucker control agent.

(423) Bilderback, T. E., R. E. Bir, et al. (1994). Managing drought on nursery crops. AG North Carolina Agricultural Extension Service(519-6): 4.

(424) Fare, D. C., C. H. Gilliam, et al. (1994). Cyclic irrigation reduces container leachate nitrate-nitrogen concentration. HortScience 29(12): 1514-1517.
Two experiments were conducted to evaluate the effects of cyclic irrigation leachate NO3(-)N concentration, container leachate volume, total effluent volume, and growth of Ilex crenata Thunb. 'Compacta'. In Expt. 1, container leachate volume was reduced 34% when 13 mm of water was applied in three cycles compared to continuous irrigation of 13 mm per unit time. Forty-nine percent less container leachate volume was collected from a continuous application of 8 mm than from that of 13 mm water. In Expt. 2, container leachate volume was reduced 71% when 6 mm was applied in a single application over 30 minutes compared to 13 mm applied continuously for 1 hour. Total effluent was reduced by 14% and 10% in Expts. 1 and 2, respectively, when 13-mm irrigation was applied in three cycles compared to one continuous irrigation. Container leachate NO3(-)N concentrations from cyclic irrigation were generally less than leachate NO3(-)N concentrations from continuous irrigation treatments. The percentage of applied N leached as NO3(-)N ranged from 46% when 13-mm irrigation was applied in three cycles to 63% when 13-mm irrigation was applied in a single cycle. Leachate NO3(-)N concentration was reduced as irrigation volume was reduced from 13 to 6 mm in Expt. 2. Percentage of applied N leached as NO3(-)N was 63%, 56%, and 47% when 13-mm irrigation was applied in one, two, and three cycles, respectively, compared to 19%,16%, and 15% when 6-mm irrigation was applied in one, two, and three cycles, respectively. 'Compacta' holly shoot and root growth were minimally affected by cyclic irrigation or irrigation volume.

(425) Kabashima, J. N. (1993). Innovative irrigation techniques in nursery production to reduce water usage. HortScience 28(4): 291-293.
Techniques implemented by 3 nurseries in Irvine, California to reduce water usage and irrigation water runoff are described. Two of the nurseries, growing outdoor containerized ornamental plants originally irrigated by overhead sprinklers, decreased water usage by 46-70% and runoff by 25-88% between 1984 and 1989 by recycling runoff, shortening irrigation times and converting to drip irrigation for plants growing in large (>7-litre) containers. The 3rd nursery, growing flowering potted plants in small (<4-litre) containers, changed from 1 heavy daily watering for 30 min to a computerized drip irrigation system applying amounts of water 5 or 6 times daily as determined by temperature, RH and wind speed. Between 1986 and 1989 water usage decreased by 30% and runoff by 77%.

(426) Hicklenton, P. R. and K. G. Cairns (1995). Plant water relations and mineral nutrition of containerized nursery plants in relation to irrigation method. Can j plant sci 76(1): 155-160.
Cotoneaster dammeri C. K. Schneid. 'Coral Beauty' and (Forsythia europaea x Forsythia ovata) Forsythia 'Northern Gold' were grown in 3.8 l containers in a softwood bark-peat-sand medium, using overhead, pulse, drop or subirrigation methods. N, P and K were supplied from Nuricote 16N-4.4P-8.1K (type 140) controlled-release fertilizer. Overhead sprinklers irrigated containers during two 45-min periods each day. Daily pulse irrigation was from sprinklers for four 7-min periods, and drip irrigation to individual containers occurred during two 5-min periods. For subirrigation, plants were placed on permanently saturated sand beds. Subirrigation resulted in significantly higher plant dry weights at the end of the growing season than all other treatments. Measured daily leaching volumes were greatest from overhead-irrigated containers, followed by drip and then pulse-irrigated containers. Leaching frrom the subirrigated treatment was small and sporadic, occurring only after moderate rainfall. Shoot water potential was measure at weekly intervals through the middle of the growing season. There were no diffences in predawn or dusk shoot water potential values between treatments, but midday shoot water potential was generally lower in subirrigated plants. At the end of the growing season, electric conductivity of the medium was highest for subirrigation, intermediate for drip and pulse irrigation, and lowest for overhead irrigation. This pattern was repeated for foliar K levels. It appears that superior growth of subirrigated plants is due more to better nutrient retention in the medium than to any effect on plant water status.

(427) Fare, D. C., C. H. Gilliam, et al. (1992). Monitoring irrigation at container nurseries. HortTechnology 2(1): 75-78.
Efficient useage of current water supplies is of great concern to container-nursery producers. Improving water management first requires knowledge of current commercial container production practives. In this study, irrigation distribution from overhead sprinklers was monitored at container nurseries to determine the distribution and the amount of irrigation applied during a typical irrigation cycle. Several nurseries surveyed had poorly designed irrigation systems; subsequently, irrigation distribution varied widely at sampling dates and within the growing-container block. Uniform distribution was achieved at some nurseries, but required careful monitoring of the irrigation system. Future water restrictions may force nurseries to improve water usage by changing irrigation delivery methods to minimize water use, resulting in reduced surface runoff and effluent from container nurseries.

(428) Hicklenton, P. R. and K. B. McRae (1989). Mineral status and growth of containerized Compact Andorra juniper under different irrigation and fertilizer regimens. Canadian Journal of Plant Science 69(4): 1295-1300.
Juniperus horizontalis 'Plumosa Compacta' were grown in 3.8 l containers to compare the factorial effects of irrigation (top vs. capillary) and controlled release fertilizer placement (incorporated vs. surface-applied) on shoot nutrient content and growth. These treatments were compared with a liquid fertilized control. Shoot N contents on 30 June (31 d after potting) were highest in plants which were top-irrigated and supplied with incorporated Nutricote, but were lowest in these plants at the end of the season (28 Sept.). Top-irrigated, Nutricote-incorporated, and liquid-fertilized plants showed the highest shoot K contents on 30 June. Lowest shoot K occurred in the top-irrigated, Nutricore-incorporated treatment on 28 Sept. In comparison with N or K, shoot P showed much less variation over the growing season. Incremental branch growth was less when fertilizer was surface-applied than when it was incorporated, but end-of-season shoot dry weights were similar in all plants except those which were top irrigated and supplied with incorporated Nutricote. This treatment produced the highest end-of-season shoot dry weight and best overall growth. Seasonal growth was positively correlated with early season (30 June) shoot N and K contents.

(429) Elliott, G. C. (1992). A pulsed subirrigation system for small plots. HortScience 27(1): 71-72.
A schematic diagram and parts list is presented for a simple and inexpensive system for pulsed subirrigation (commercially referred to as ebb and flow or flood and drain). The system can be readily

modified for flowing solution culture. It has proven useful in teaching and research applications. It can be assembled from readily available parts using hand tools.

(430) Karam, N. S. and A. X. Niemiera (1994). Cyclic sprinkler irrigation and pre-irrigation substrate water content affect water and N leaching from containers. Journal of Environmental Horticulture 12(4): 198-202.
A series of sprinkler irrigation experiments were conducted to determine the influences of water application rate (WAR), pre-irrigation substrate water content (PSWC), and cyclic irrigation on water and N leaching from container-grown plants. Prior to experiments, Marigold, were glass house-grown in pine bark-filled 3.8 l containers. Prior to treatment, substrate was dried via evapotranspiration (ET) to targeted PSWCs. A simulated overhead irrigation system applied the daily water allotment in a single continuous application or cyclically (multiple applications); in most cases the respective ET volumes were applied to the substrate. Water application efficiency (WAE; water vol retained in substrate /water vol applied to substrate) was determined, and in some experiments, leachates were analyzed for EC, NO3-N and NH4-N. A negative linear relationship existed between WAR and WAE. Leachate NO3-N and NH4-N concentrations were unaffected by WAR, however, total N leached increased with increasing WAR. WAE of cyclic irrigation was 4% higher (absolute basis) than with continuous irrigation; WAE increases as the time interval between cyclic applications increased from 20 to 60 min. Regardless of how water was applied, WAE was inversely related to PSWC and application volume. These experiments showed that the most effective method to increase WAE is to irrigate at relatively low PSWCs; if irrigation occurs at relatively high PSWCs, then relatively low volumes should be applied.

(431) Beeson, R. C., Jr. and J. Haydu (1995). Cyclic microirrigation in container-grown landscape plants improves plant growth and water conservation. Journal of Environmental Horticulture 13(1): 6-11.
Four trees (Acer rubrum L., Ulmus alata Michx.,Quercus virginiana Mill. and Lagerstroemia indica L.) and two landscape shrub species (Rhododendron indicum L. 'Formosa' and Elaeagnus pungens Thunb.) were grown in 10-liter (#3) polyethylene containers. Plants were irrigated with overhead impact sprinklers (control) or with individual low volume spray stakes. Microirrigated treatments consisted of same or double volume per day per container as controls applied as one to three cyclic subvolumes. Shrub growth was seldom influenced by irrigation treatment. Xeric tree species (U. alata and Q. virginiana) grew as well with single volumes applied in 2 cycles as double volumes applied in 3 cycles; both produced significantly larger trees than the control. Mesic species (A. rubrum and L. indica) irrigated with double volumes in 3 cycles produced the largest trees that were significantly larger than single volume microirrigated or control trees. Growth of single cycle,, single volume trees (overhead and microirrigation) was equivalent; thus, growth effects were due to cycling, not microirrigation. With commercially representative container spacing used, superior tress were produced with cycled microirrigation using 25% (xeric) or 50% (mesic) of the water volume per area applied through the overhead sprinkler. Further aspects of irrigation requirements and water efficiency are discussed.

(432) Hoadley, B. and D. L. Ingram (1982). Drip irrigation for the woody ornamental nursery. Southern Florist and Nurseryman 95(14): 20-22.

(433) Martin, C. A., H. G. Ponder, et al. (1989). Effects of irrigation rate and media type on growth of Acer rubrum L. Journal of Environmental Horticulture 7(1): 38-40.
Acer rubrum L. seedlings were grown in 38 l (#10) containers with 4 irrigation rates of 50%, 100%, 200%, 400% replacement of net evaporation and 3 media types of 100% pine bark; pine bark:sand (4:1 by vol); pine bark:sand (3:2 by vol). A spray stake irrigation system was used to irrigate. Height growth was not affected by irrigation rate. Caliper growth increased cubicly and linearly with increased irrigation rate during the first and second years, respectively. Media affected height and caliper growth the second year only. Height and caliper growth increased linearly with increased sand content. An increase in irrigation rate produced a larger root system, while an increase in sand content increased primary and secondary root growth.

(434) Gonzalez, R. A., D. K. Struve, et al. (1992). A computer-controlled drip irrigation system for container plant production. HortTechnology 2(3): 402-407.
An irrigation control system has been developed and used to estimate evapotranspiration of container-grown plants by monitoring randomly selected plants within a container block and watering on an 'as needed' basis. Sensor reliability and operational ease allows application of the system in a wide variety of field conditions. First-year test, using red oak seedlings, showed a reduction of 95% or better in both total irrigation and leachate rates with the computer-controlled, drip irrigation treatment without reducing plant growth.

(435) Furuta, T. (1973). New irrigation system speeds water to entire nursery. American Nurseryman 138(9): 13, 93-100.

(436) Smith, E. M. and S. A. Treaster (1983). Root pruning landscape plants produced on sand capillary beds using Gloquat C, a sanitizing agent, capillary irrigation, container nursery stock. Research Circular Ohio Agriculture Research Development Center(274): 36-37.
Gloquat C was evaluated for root pruning forsythia and weigela produced on a sand bed capillary irrigation system. The recommended rate of 5.25 oz/100 sq ft treatment pruned the roots of forsythia at an acceptable percentage throughout the summer. Weigela was satisfactorily pruned for 2 months at 5.25 oz and for 3 months at 10.5 oz. A reduction in height growth was observed at the 10.25 oz/ 100 sq ft rate with forsythia and 15.75 oz/ 100 sq ft treatment rates with weigela.

(437) Whitcomb, C. E., C. Gray, et al. (1984). Capillary water beds for container nursery stock in Oklahoma. Research Report P Agriculture Experimental Station Oklahoma State University(855): 9-12.

(438) Green, J. L. (1989). Special report: practices to minimize contamination of groundwater and runoff water in greenhouse and nursery production of container-grown plants. Ornamentals Northwest Cooperative Extention Service Oregon State University 13(3): 10-16.

(439) Seymour, N. G. (2000). Guide to Establishing a Nursery in Alberta, Alberta Agriculture Food and Rural Development. 2000.
This guide provides the reader with the basics of setting up a nursery. Includes information on productions systems, machinery & equipment, site selection, field production, plant choice, propagation systems, container growing, pest management, business and list of sources/resources

(440) Burafuta, E. (2000). Economic overview of farm incomes: Greenhouse and Nursery Farms. Bulletin Series 1(8): 16.
This document summarizes economic data (operating income, greenhouse and nursery sales, etc..) by province, concentration of

production, degree of specialisation, and more for 1996.

(441) Grubich, L. (1998). No data equals fewer pesticides - grower support is needed to recharge the pesticide data program to preserve key pesticide uses. Fruit Grower(March): 47.

(442) Anon. (1998). Crop protection roundup. Fruit Grower(March): 30, 32.
A list of new insecticides, biologicals and plant growth regulators available for fruit and nut crops (US)

(443) Hicklenton, P. R. (1990). Growth of capillary-irrigated Andorra juniper and Sarcoxie euonymus as affected by controlled release fertilizer type and placement. Journal of Environmental Horticulture 8(2): 92-95.
Juniperus horizontalis Moench. 'Plumosa compacta' and Euonymus fortunei Turcz. 'Sarcoxie' were grown on a sand capillary bed with two types of controlled release fertilizer (3:1 Type 100:Type 40 Nutricote 16N-4.8P-8.1K (16-10-10), and Osmocote 18N-2.6P-9.7K (18-6-12) either medium-incorporated , surface-applied or dibbled below the roots. Throughout the growing season, neither leaf area, root or shoot dry weight of euonymus was affected by fertilizer type or placement. Branch length growth and dry weight of juniper was not affected by fertilizer type when fertilizer was surface-appled or medium incorporated. Dibbled Osmocote produced similar results, but dibbled Nutricote resulted in poor root and shoot development in juniper throughout the season. Medium soluble salt concentration (determined on container leachate) was 2800 dS/m in the dibbled Nutricote treatments in June (approximately 2.5 times higher than that in the other treatments). Soluble salts decreased between June 21 and August 16 in all treatments and then remained quite constant until the end of the season (September 13).

(444) Warren, S. L. and F. A. Blazich (1991). Influence of container design on root circling, top growth, and post-transplant root growth of selected landscape species. Journal of Environmental Horticulture 9(3): 141-144.
'Delaware Valley White' azalea, 'Green Luster' holly, 'Plumosa compacta Youngstown' juniper, and 'Shasta' viburnum were grown for 1 to 2 years in four container designs: a conventional straight-walled round container, a square container with corner holes, a round container with stepped-pyramid profiles, and a poly bag. Poly bag, square, and stepped-pyramid containers significantly reduced root circling on all species compared to the traditional straight-walled round container. There were not significant differences in root circling among the three designs. Top growth was harvested at the end of 1 and 2 years. Effect of container design on top dry weight was species dependent. Poly bag, square, and stepped-pyramid containers increased top growth by 11 to 23% compared to the straight-walled round container. However, no one design was consistently superior for 2 years compared to the straight-walled round container. In addition, three of four species did not respond to container design 1 out of 2 years. Plants were transplated into the landscape after growing for 1 or 2 years in the containers. After 16 weeks in the landscape, 'Green Lushter' holly initially grown in poly bag, square, and stepped-pyramid containers had greater new root dry weight and smaller shoot (top):root ratios compared to the straight-awalled round container. Top and new root dry weight of 'Shasta' viburnum were significamly affected by container design. However, the shot:root ratios were not significantly different compared to the straight-walled round container. In the landscape, container design did not significantly affect top dry weight, new root dry weight or shoot:root ratio of 'Plumosa Compacta Youngstown' juniper.

(445) Keever, G. J. and G. S. Cobb (1989). Comparison of propagation and transplanting sequences for container production of four woody landscape plants. Appl Agric Res 4(3): 222-225.
Seven propagation and transplanting sequences were compared for the container production of "Basham's Party Pink" crapemyrtle (Lagerstroemia indica X L. fauriei), "Blue Pacific" juniper (Juniperus conferta Parl.), 'George Tabor' azalea (Rhododendron X sp.), and "Hino Crimson" azalea (Rhododendron X sp). Cuttings propagated in 3-L (0.8-gal) containers were slower to root than those propagated in cell pacs or 8-cm (3-in.) containers; however, percent rooting did not differ among treatments. After 12 months, shoot and root growth were generally greatest for cuttings propagated in larger containers and least when cuttings were rooted in cell pacs and subsequently transplanted into 8-cm and then into 3-L containers. Two cuttings per container increased growth per container for azalea and juniper but not for crapemyrtle.

(446) Pellett, H., R. Hummel, et al. (1980). Relationship of fall watering practice to winter injury of conifers. Journal of Arboriculture 6(6): 146 - 149.

(451) Riviere, L. M., J. C. Foucard, et al. (1990). Irrigation of container crops according to the substrate. Scientia Horticulturae 43(3-4): 339-349.
Two trials were conducted to determine how adequate the quantity of water was provided at each watering of container crops and the properties of the substrates. One trial dealt mainly with water availability and the other with aeration. The plants utilized were shrubs and conifers. For the plants with high water needs, best results were obtained with high water availability (30% vol.), medium aeration (20% vol. at 10 cm water tension), and frequent irrigation with rather small water quantity; in plants with low low water needs, it seemed preferable to utilize substrates with medium to high water availability (20-30% vol.), and less frequent irrigation with a great amount of water. A good growth depends on the ajustment of the amount of water to the needs of the plants, in relation with the aeration of the substrates.

(452) Fitzpatrick, M. J. and M. A. Lemay (2000). Innovations for irrigation and water recycling in nursery operations. Landscape Trades 22(1): 56, 58 - 60.

(453) Chong, C. and P. Purvis (2000). Serching for nonchemical alternative to container weed control. Landscape Trades 22(1): 48.

(454) Anon. (1978). Ornamental Crops - Program 25. Report of the agricultural research institute of Ontaria(April 1, 1977 - March 31, 1978): 78 - 83.

(455) Whitcomb, C. E. (1974). Response of Juniperus chinensis Pfitzeriana and Ilex cornuta Burford to 3 levels of Osmocote 18-6-12 and 3 levels of micronutrient fertilizer in 3 container sizes. Res Rep P OSU Agric Exp Stn Okla State Univ, Oct 704: 24-29.

(456) Whitcomb, C. E. (1974). Response of Juniperus chinesis Pfitzeriana and Ilex cornuta Burford to 3 levels of dolomite and 3 levels of single superphosphate in the growing medium in 3 container sizes. Res Rep P OSU Agric Exp Stn Okla State Univ, Oct 704: 30-34.

(457) Whitcomb, C. E. (1977). A comparison of Osmocote 18-6-12, 18-5-11 and IBDU-K [isobutyldyene diurea] frit on growth of pfitzer juniper and dwarf burford holly [Juniperus chinesis, Ilex cornuta]. Res Rep P Okla Agric Exp Stn, Oct 760: 91-95.

(458) Jackson, G. E., J. Irvine, et al. (1995). Abscisic acid concentrations and fluxes in droughted conifer saplings. Plant Cell

and Environment 18(1): 13-22.
We present the first study of abscisic acid (ABA) concentrations and fluxes in the xylem sap of conifers during a drought cycle. In both Pinus sylvestris and Picea sitchensis the concentration of ABA in the sap rose 11-fold as the drought progressed. There were clear diurnal trends in this concentration, which reached its maximum (6-8 mmol ABA m-3) near the middle of the day. The fluxes of ABA were calculated by multiplying the xylem ABA concentration by the sap flow rate. The ABA fluxes in the droughted plants in the middle of the day were usually no higher than those of the controls, as a result of the very low sap flow in the droughted plants at that time. However, the ABA flux in the droughted plants was higher than in the controls in the morning, and we postulate that the stomata are responding to these 'morning doses'. Stomatal conductance, g-s, could not be related statistically to leaf turgor or to the ABA flux. However, g-s did display a negative exponential relationship with ABA concentration in the xylem. Pinus displayed more acclimation to drought than Picea. Its ABA concentration rose and its stomatal conductance fell at day 6 of the drought, as opposed to day 17 for Picea, and its osmotic potential fell during the drought treatment.

(459) Chrustic, G. A. and R. D. Wright (1983). Influence of liming rate on holly, azalea, and juniper growth in pine bark. Journal for the American Society of Horticulture Science 108(5): 791-795.
Rooted cuttings of Ilex cranata Thunb. 'Helleri', Rhododendron obtusum Planch. 'Rosebud', and Juniperus chinensis L. 'San Jose' were grown in a 100% pine-bark medium amended with dolomitic limestone at 0 to 8 kg m-3 with resulting pH from 3.4 to 7.2. Except for juniper at 2 kg m-3, growth was not increased by liming, and 8 kg m-3 tended to reduce shoot and root growth. This reduced growth was attributed in part to greater NH4 adsorption by the bark, reducing tha maount available for plant uptake, and a higher nitrifiaction rate, leading to an elevated NO3 to NH4 ratio in the medium. Liming pine bark to improve growth of these woody plants may be unnecessary.

(460) Colombo, S. J. and E. M. Raitanen (1991). Frost hardening in white cedar container seedlings exposed to intermittent short days and cold temperatures. For Chron 67(5): 542-544.
Shoot frost hardiness development in white cedar (Thuja occidentalis L.) container seedlings in response to intermittent short days (4 days per week) and warm (not less than 15 degrees C) or cool (10/5 degrees C, day/night) temperatures was assessed using the diffusate-electrical conductivity technique. A slight increase in frost hardiness was found within 2 weeks of the start of warm, short days. Frost hardiness increased linearly with time under warm, short days from week 7 to week 14, with seedlings being resistant to damage at -10 degrees C on week 14. Approximately one-quarter of the seedlings developed brown-green foliage colour after 5 weeks of warm, short day treatment. These seedlings were significantly more frost hardy than the remainder of the seedlings which had dark green foliage. Seedlings exposed to warm, intermittent short days for 13 weeks and then to cool continuous short days for a further 6 weeks became hardy to -20 degrees C, while seedlings exposed to warm, intermittent short days only for the full 19 week period did not harden to the -20 degrees C level.

(461) Walker, K. L. and D. J. Williams (1990). Weed interference in container-grown "San Jose" juniper. HortScience 25(6): 650-651.
Experiments in two consecutive years indicated that barnyardgrass (Echinochloa crusgalli L.), large crabgrass (Digitaria sanguinalis L.), and giant foxtail (Setaria faberi Herrm.) reduced growth of container-grown 'San Jose' juniper (Juniperus chinensis L. 'San Jose') 83 days after tranplanting grass seedlings into the containers. Grass densities of one to six weeds per container reduced 'San Jose' juniper growth. By 83 days of grass interference, juniper shoot dry weight was reduced as much as 43% by six weeds per container.

(462) Niemiera, A. X. and R. D. Wright (1986). The influence of nitrification on the medium solution and growth of holly, azalea, and juniper in a pine bark medium. Journal for the American Society of Horticulture Science 111(5): 708-712.
Three genera of woody plants were container-grown in a pine bark medium. Pine bark was amended or unamended with nitrapyrin (NI) and fertilizerd with an NH4-N fertilzier. Medium solution NH4-N concentration of bark without NI decreased rapidly for the first 3 to 5 weeks with a concomitant increase in NO3-N concentrations. Medium solution pH at 0 NI decrased 0.8 unit during periods of rapid NO3-N accumulation. The low medium solution pH of the 0NI treatment resulted in solution Ca, Mg, and Mn concentrations that were several times greater than at 82 micrograms of NI. Correspondingly, tissue concentrations of these ions were generally greater at the 0 l treatment than at the 82 micrograms NI treatment. In geneari, there were no differences in shoot dry weight in response to NI treatment. Results indicate that nitrification is important in the nutrition of container-grown plants

(463) Chong, C., R. L. Desjardins, et al. (1979). Changes in water and carbohydrate status of three nursery species in containers during overwinter storage in three environemnts. Can j plant sci 59(3): 747-755.
During overwinter storage in an open coldframe, a shaded single-layer polyhouse, and an unshaded double-layer polyhouse, changes in water potentials, moisture content, soluble sugars, and starch were compared in shoots of Colorado spruce (Picea pungens Egnelm.) and Ramlosa juniper (Juniperus sabina L. 'Ramlosa'), both container-grown for one season, and also of globe cedar (Thuja occidentalis L. 'Woodwardii'), field potted 1 mo prior to testing. Higher water status and higher sugar and saitch content were observec i n all species in the polyhouse than in the coldframe. Differences between effects of the polyhouses were less clear-cut. During the storage period, higher water status and higher soluble sugars were genearlly observed in spruce than in juniper and cedar. The sugar to starch ratio (an index of metabolic activity) remained relatively constant for juniper and cedar but decreased during the period of storage for spruce. Extent of winter injury, as indicated by post winter storage condtions of plants, was 10 and 40% less for cedar and juniper, respectively, overwintered in the polyhouses than in the coldframe; spruce survived equally well in all three environments.

(464) Olsen, J. E., O. Junttila, et al. (1997). Ectopic expression of oat phytochrome A in hybrid aspen changes critical daylength for growth and prevents cold acclimatization. Plant Journal 12(6): 1339-1350.
Survival of temperate-zone tree species under the normal summer-winter cycle is dependent on proper timing of apical growth cessation and cold acclimatization. This timing is primarily based on the perception of daylength, and through evolution many tree species have developed photoperiodic ecotypes which are closely adapted to the local light conditions. The longest photoperiod inducing growth cessation, the critical photoperiod, is inherited as a quantitative character. The phytochrome pigment family is the probable receptor of daylength, but the exact role of phytochrome and the physiological basis for the different responses between photoperiodic ecotypes are not known. This report shows for the first time that over-expression of the oat phytochrome A gene (PHYA) in a tree significantly changes the critical daylength and effectively prevents cold acclimatization. While the critical day

length for elongation growth in the wild-type of hybrid aspen (Populus tremula X tremuloides) was approximately 15 h, transgenic lines with a strong expression of the oat PHYA gene did not stop growing even under a photoperiod of 6 h. Quantitative analysis of gibberellins (GA) as well as indole-3-acetic acid (IAA) revealed that levels of these were not down-regulated under short days in the transgenic plants expressing high levels of oat PHYA, as in the wild-type. These results indicate that photoperiodic responses in trees might be regulated by the amount of PHYA gene expressed in the plants, and that the amount of phytochrome A (phyA) affects the metabolism of GAs and IAA.

(466) Smith, D., C. Gilliam, et al. (1998). Going to Waste. American Nurseryman(October 15): 30 - 32, 34.
Research shows taht paper pellets control weeds in container nurseries without harming plants or the environment

(467) McNamara, S. and H. Pellett (2000). Cold hardiness of Phellodendron sachalinense Friedr. Schmidt seedlings increases with age. HortScience 35(2): 304-305.
Seedlings of several landscape tree species frequently experience cold injury at temperatures that are noninjurious to older specimens of the same species. However, there are few published reports quantifying age-related differences in hardiness. In this study, the stem cold hardiness of a mature, 35-year-old female Sakhalin corktree was compared with that of half-sib seedling progeny of different ages. Ten-, 22-, and 34-month-old seedlings were hardy to -4 degreeC on 9 Oct., while the 35-year-old parent withstood -12 degreeC. Ten-month-old seedlings exhibited no further increase in hardiness on 26 Oct., whereas the 34-month-old seedlings and the mature parent were hardy to -16 degreeC. The 22-month-old seedlings were intermediate in hardiness on this date. The 10- and 22-month-old seedlings had died back to the snowline by late January, but the 34-month-old seedlings and the mature tree were uninjured. The corktree seedlings did not attain midwinter hardiness levels comparable to the adult tree until the winter following their fourth season of growth. The absence of flower buds on cold-tolerant 4- and 5-year-old seedlings suggests that physiological maturation is not a prerequisite for full expression of the cold acclimation capability of this species.

(468) Wilner, J. and E. J. Barch (1974). Hardiness of roots in relation to shoots of container-grown plants by an electric method. Can. J. Plant. Sci. 54: 281 - 289.
A 2-yr study showed that the bioelectric method was sensitive and reliable to test winter hardiness of roots of container-grown palnts and to determine the effects of seasonal changes on their cold-hardening. This provides possibilities for overcoming the difficulties of studying simultaneously the factors affecting winer hardiness of roots in close association with shoots of overwintering plants. The findings may be of special importance to the production of container-gorwn nursery stock palnts because, due to the restircted root systems, their winter survival si closely related to the forst hardiness fo their roots. The differences int he ahrdening capacity of roots and shoots were quantitatively expressed as ratios of impedance. An impendance reading of about 85,000 ohms for roots, with a shoot/root ratio of 2.1:1.0, and a temperature of soil and air of 1.7 and -3.9 C., respectively, were fournd to be an optimum condition for overwintering of container stock. The correlations between the impendance measurements and the temperature of soil and air were used as guides for determining viable conditions for overwintering plants.

(469) Ball, J. (1987). Influence of fall planting dates on the survival and growth of Taxus, Thuja, and Viburnum species. HortScience 22(6): 1289-1290.
The influence of soil temepartuer on the survival and growth of fall transplanted Tauntanii yew (Taxus x media Rehd., 'Tauintonii'), Tehcny arborvitae (Thuja occidentalis L. 'Thechny') and American cranberry viburnum (Viburnum trilobum Marsh.) was investigated. Soil temperature appears to be a critical factor in the success of yew plantings, but less so for arborvitae and viburnum. Planting should be made ~ 4 weeks before soil temperatures in the root zone reach 7 C.

(470) Einert, A. E. and G. Guidry (1975). Rice hulls and hull compost in growing media for container-grown junipers [Juniperus]. Arkansas Farm Research 24(3): 2.

(471) Chong, C. (1992). Apple pomace as an amendment in container growing media. HortScience 27(10): 1138.

(472) Bugbee, G. J. (1996). Growth of Rhododendron, Rudbeckia and Thujia and the leaching of nitrates as affected by the pH of potting media amended with biosolids compost. Compost sci util 4(1): 53-59.
A conventional potting media containing peat moss, softwood bark and sand was amended to contain 0, 25, 50, 75 and 100 (percent vol-1) municipal compost made from yard waste and biosolids. Each medium was adjusted with limestone and sulfur to an approximate pH of 5.0, 6.0 or 7.0. Rhodendron Panticum L. 'Anah Kruschke' (Rhododendron), Thujia occidentalis L. (arborvitae) and Rudbeckia hirta L. 'Goldilocks' (Black-eyed Susan) were grown in each medium and pH level for 18 months. Leachate from pots was tested for NO3-N and NH3-N+NH4-N to determine how media pH and the amount of compost effected the potential for potting media to be a source of nitrate in surface and ground water.

Media pH affecte plant gorwth more than the percent compost. Compared to media with a pH of 7.0, statistically significant increases in the gorwth of Rhododendron occurred in media with a pH of 5.0 or 6.0. this pH effect was similar but less pronounced for Tjujia. Growth of Rudbeckia was not effected by media pH or percent compost. Media with 0 and 25 percent compost leached the least nitrogen regardless of pH. media with 75 and 100 percent compost at pH 5.0 and 6.0 leached the most nitrogen. The increase in nitrogen leaching in the more acidic media was associated with higher concentrations of NH3-N + NH4-N. Nitrogen in leachate was greatest during the four weeks immediately after the pots were placed in the field and four weeks after fertilizer was applied in June of the second year of the experiment.

(473) Griffin, J. J., S. L. Warren, et al. (1999). Nitrogen nutrition of containerized Thuja x 'Green Giant'. Journal of Environmental Horticulture 17(2): 76-79.
Rooted stem cuttings of 'Green Giant' arborvitae (Thuja L. x 'Green Giant') were grwon in 3.8 liter (#1) plastic containers containing a pin bark:sand (8:1 by vol) substrate. Plants were fertilized three times weekly for 15 weeks with a complete nutrient solution at N application rates (NARs) of 0, 10, 20, 40, 80, 160 or 320 mg/liter (ppm) supplied as ammonium nitrate (NH4NO3). Both shoot and root dry weights were significantly affected by NAR. Maximum shoot weight, as predicted by a quadratic plateau model, was reached at a NAR or approximately 100 mg/liter (ppm), representing a 200% increase of controls [0 mg/liter (ppm) N]. Maximum and minimum root dry weights occurred at 0 mg/liter (ppm) N and approximately 50 mg/liter (ppm) N, respectively, representing a 37% decrease. Root lenght decreased 36% at a NAR of approximately 50 mg/liter (ppm). Root diamter (root area / root length) increased before reaching a plataeau at aproximately 130 mg/liter (ppm) N indicateing that root lenght decreased faster than root area at low N concentrations. Soot concentrations of N, P, Mg, and S were maximized at

approximately 71, 41, 48 and 52 mg/liter (ppm) N, respectively. Uptake of K and Ca were unaffected by N concentrations.

(474) Binder, W. D., P. Fielder, et al. (1990). Temperature and time-related variation of root growth in some conifer tree species. CANADIAN JOURNAL OF FOREST RESEARCH 20(8): 1192-1199.

The variability of root growth potential of cold-stored (2 degree C) bare-root and container-grown stock of Abies grandis (Dougl.) Lindl., A. amabilis (Dougl.) Forbes., Picea sitchensis (Bong.) Carr., Pseudotsuga menziesii (Mirb.) Franco, Thuja plicata Donn, and Tsuga heterophylla (Raf.) Sarg. was tested under four air temperature regimes for 7 and 14 days. In P. menziesii, P. sitchensis, and T. plicata, root growth was greatest under the 25:20 degree C (light:dark) regime, whereas the 30:25 degree C (light:dark) regime was supraoptimal for all species. Temperatures cooler than 25:20 degree C (light:dark) were optimal for T. heterophylla and A. amabilis. A 14-day test duration consistently produced more roots than the 7-day test. Container-grown seedlings produced more new roots than bare-root seedlings. Except for P. sitchensis and T. plicata, light was required for root growth. The effect of test conditions on root growth is discussed with respect to a possible relationship between temperature optima for root growth and current photosynthate production. High within-test variability and inconsistent ranking of seed lots under different test temperatures and durations suggest that stock quality interpretations based solely on root growth potential tests should be questioned.

(476) Smith, E. M. (1978). Juniper [Juniperus horizontalis] growth in hardwood and pine bark mixtures. Am-Nurserym, July 1, 1978, 148(1): 27, 232, 234.

Plants of Juniperus horizontalis cv. Plumosa (Youngstown selection) were potted-on into 2-gal containers with hardwood bark either alone or in various proportions with sand, or soil/peat/sand, or pine bark/vermiculite mixtures (analyses given). Growth after 2 growing seasons was greatest in pine bark/vermiculite and soil/peat/sand, and differed little between the hardwood bark/sand mixtures.

(477) Ruter, J. M. and H. v. d. Werken (1986). Is dolomitic limestone overused in container media? American Nurseryman 163(12): 49...57.

In container growing it is often common practice to add lime to raise the pH of organic media such as peat moss or pine bark, which tend to be acidic. Dolomitic limestone is generally preferred to CaCO3 as it provides both Ca and Mg. Recent research, mostly involving holly (including Ilex crenata), azalea and juniper (including Juniperus virginiana and J. horizontalis), is reviewed. The need to increase the pH is questionable since container-grown plants appear to grow well in soilless media at a pH range (pH 5-6) lower than that generally recommended for mineral field soils. Dolomitic limestone applied at rates ranging from 6 to 14 lbs/yd3 may actually reduce plant growth, probably by lowering the amount of nitrogen available as NH4+. One study showed that < 3.5 lb/yd3 was actually required to bring the pH of a number of media within the range pH 5-6. Leaching of the Mg fraction due to the high solubility of MgCO3 may result in Mg deficiency, particularly with the use of small dolomite particles; MgSO4 application is suggested as an alternative. Finally, the importance of determining the levels of Ca and Mg in the water supply, and of adjusting the dolomite application rates accordingly, is discussed.

(478) Fretz, T. A. (1973). Herbicide-impregnated mulches for weed control in container nursery stock. Scientia Horticulturae 1(2): 165-170.

Chlorpropham, chlorpropham plus p-chlorophenyl-N-methylcarbamate (PPG-124), EPTC, diphenamid and dichlobenil were evaluated for plant tolerance and weed control when incorporated in a milled pine bark mulch and applied at a depth of 1.27 cm to container-grown plants of Rhododendron, Ilex, Juniperus and Ligustrum spp. During 2 seasons all impregnated mulches, except with EPTC at 5.6 kg/ha and diphenamid at 5.6 kg/ha, provided adequate long-season broadleaf weed control. Similarly, long-season grass weed control was acceptable with all herbicide-impregnated mulches, except chlorpropham at 2.2 kg/ha, chlorpropham plus PPG-124 at 2.2 plus 0.4 kg/ha, and diphenamid at 5.6 kg/ha. Plant injury occurred in all species when the mulch contained dichlobenil at 13.4 kg/ha.

(479) Smith, E. M. and S. A. Treaster (1988). Growth response of Euonymus, juniper and azalea treated with differing rates of Osmocote 18-6-12. Spec Circ Ohio Agric Res Dev Cent(115): 4-5.

(480) Kjelgren, R. (1996). Irrigation timing of three landscape shrub species based on foliage temperature. Arboricultural Journal 20(1): 47-57.

Changes in foliage temperature with vapour pressure deficit and water stress fro three shrub species were investigated for use in irrigation scheduling in landscapes. Midday leaf-minus-air temperature (Tl - Ta) and vapour pressure deficit were monitored seasonally for prostrate juniper (Juniperus horizontalis 'Wiltonii'), upright juniper (J. chinensis 'Hetzi), and dwarf red-stem dogwood (Cornus sericea 'Kelseyii), positioned as isolated plants or in a massed sening. There was an inverse baseline relationship between Tl - Ta and vapour pressure deficit for all species and both spacings under well-watered conditions. This was consistent with baselines reported for herbaceous crops, but with substantially more scatter. Baseline relationships between speacings were similar for upright juniper and dogwood, but not for prostrate juniper. During a dry-down cycle Tl - Ta exceeded the well-watered baseline for dogwood and upright juniper, signaling incipent water stress. Stress was confirmed in declining predawn leaf water potential and water content of the container media. Due to more water loss, increase in Tl - Ta over the baseline occurred more rapidly in isolated plants in both species. Foliage temperature readings of prostrate juniper were confounded by sparse canopy that transmitted background radiation. The results suggest that irrigation of certain shrubs in a landscape with dense canopies can be timed to increases in Tl - Ta. This method will not work well for shrubs with sparse crowns and under shady, humid conditions.

(481) Whitcomb, C. E., J. Rackley, et al. (1976). Growing nursery stock from multiple liners. American Nurseryman 144(6): 13, 32, 34, 36, 38.

One, 3 or 5 established rooted cuttings of Ligustrum japonicum and Viburnum suspensum were placed in 1-gal containers and fertilized once every fortnight at 500, 1000 or 1500 lb N/acre/year. The number of bud-breaks which subsequently developed on one plant/container was not affected by N level, but with 3 and 5 plants/container bud-breaks increased by 19 and 24% at the medium and highest N rates, respectively. Moreover, plant quality was greatly enhanced with 3 or 5 plants/container, and top and root weights increased by up to 61% at the highest N level. These beneficial effects were reflected in better plant growth 4 years after field planting. In another trial in which juniper cuttings were struck either into 2-gal containers with 1, 3 or 5 cuttings/container or into 2.5-inch pots and transplanted, when rooted, into containers at the same density, similarly beneficial results were obtained with increasing numbers of plants/container; differences between the 2 propagating methods were slight. In another trial in which 1, 2 or 3 rooted cuttings of juniper were transplanted into 1-gal containers, incremental enhancement of quality and top weight

amounted to about 24 and 7% with 2 and 3 plants/container, respectively. The relative advantages of 3 or 5 plants/container are discussed in relation to the increased cost of production.

(482) Furuta, T. (1976). Nitrogen fertilization of container-grown ornamentals. American Nurseryman 142(12): 14, 106-109.
The results are summarized of several trials with ornamental trees and shrubs, including pyracantha, juniper and privet, grown on raised benches irrigated daily by several different methods, and supplied with N in the irrigation water, as soil-incorporated Osmocote or 1BDU, or as foliar applications, either alone or together. Data are presented on plant growth and on the nitrate-N content of the run-off water. The largest plants were obtained with Osmocote + liquid feed. 1BDU was effective as Osmocote or constant fertilization alone.

(483) Chong, C. and R. L. Desjardins (1981). Comparing methods for overwintering container stock. American Nurseryman 153(1): 8-9, 131.
The results are given of a large-scale evaluation of 19 different types of overwintering environments, with Juniperus chinensis, Thuja occidentalis and Taxus X media cvs as test plants. Groups of plants were placed upright in single or double-layer polyethylene greenhouses (Quonset and Filclair types, respectively), the roofs of which were covered with white latex paint, or on their sides under painted structureless polyethylene blankets, or upright in the open (controls). The sub-treatments comprised covering the plants with a layer of microfoam during the coldest months, or not, leaving snow on the protective covering or clearing it, or placing air-bubble type insulation (Aircap) inside the main cover, or not, in various combinations. The microfoam was removed on 21 March and the polyethylene blanket on 10 April. All 3 main types of cover gave good protection, with little difference between that provided by single- vs. double-layer polyethylene; average temperatures during January, however, were slightly higher under the latter. Covering the plants with microfoam and leaving a snow cover were beneficial, the latter especially with the blanket protection; with no snow cover plants suffered leaf burn or desiccation associated with excessive heat build-up on sunny days. The addition of Aircap insulation made little difference.

(484) Whitcomb, C. E. (1974). Effects of pot sizes on rooting of juniper cuttings. American Nurseryman 139(2): 15, 73-75.
Root cuttings of Juniperus chinensis rooted best in containers with a volume of 36.5 in3; larger container sizes made little difference. With Euonymus japonicus, however, rooting was not affected by container size.

(485) Smith Michael, W., L. Carroll Becky, et al. (2000). Mulch improves pecan tree growth during orchard establishment. Hortscience-. April, 2000; 35(2): 192-195.
'Giles' pecan (Carya illinoinensis (Wangenh). K. Koch) seedlings were either not mulched or mulched with wood chips arranged in a 1- or 2-m-wide square that was 30 cm deep. Mulch treatments were in factorial combination with two N rates applied as either a single application at budbreak or as a split application at budbreak and 3 weeks later. Tree height was positively related to mulch width each year of the 3-year study, and trunk diameter was positively related to mulch width during the second and third years of the experiment. Leaf P and K concentration during 2 years and leaf N during 1 year of the study were positively related to mulch width. Trees receiving the higher N rate were taller during 2 of 3 years, but leaf N concentration was not affected by N rate. No differences in the parameters measured were observed whether N was applied as a single or as a split application.

(486) Hakam, N., S. Khanizadeh, et al. (2000). Assessing chilling tolerance in roses using chlorophyll fluorescence. Hortscience-. April, 2000; 35(2): 184-186.
Chlorophyll fluorescence (CF) was evaluated as a technique to assess chilling injury of rose (Rosa sp.) leaves exposed to low temperatures. In the more susceptible genotypes, variable fluorescence (Fv) decreased dramatically as the temperature was lowered. In the less susceptible genotypes, Fv was more stable and decreased more slowly as temperature fell. Our results suggest that measurement of CF may provide a rapid method to prescreen genotypes for chilling susceptibility, as required in plant breeding.

(487) Sartain, J. B. and D. L. Ingram (1984). Influence of container medium, lime, and nitrogen source on growth of woody ornamentals. Journal for the American Society of Horticulture Science 109(6): 882-886.
Juniperus horizontalis 'Andorra Compacta' and Rhododendron simsii 'Redwing' were grown for 6 months in 3 media to evaluate selected nutrient sources at 2 lime levels. Sulfur-coated urea (SCU) induced the lowest final medium pH and isoburylidene diurea (IBDU) induced the highest. Lime application to the 2 Canadian peat : 1 calcined clay medium (v/v) was detrimental to 'Redwing' azalea shoot growth. Nutrient source did not affect shoot or root growth of azaleas growing in the other nutrient sources. Liming decreased juniper shoot growth in the 1 pin bark : 1 Canadian peat : 1 sand medium (by volume). Oxamide and Osmocote produced significantly more juniper shoot growth in the pine bark : sand and pine bark : Canadian peat : sand media than other nutrient sources. After 6 months, plants fertilized with either IBDU or SCU had a higher concentration of leaf N than did those fertilized with Osmocote (18N-2.6P-10K)

(488) Niemiera, A. X. and R. D. Wright (1986). Effect of liming rate on nitrification in a pine bark medium. Journal of the American Society for Horticultural Science 111(5): 713-715.
A 100% pine bark medium was amended with dolomitic lime at 0, 3 or 6 kg/m3 and periodically fertilized with 210 ml of a nutrient solution containing 100 p.p.m. N as (NH4)2SO4. At the 3- and 6-kg lime treatments, medium solution NH4-N concentrations decreased rapidly while NO3-N concentrations increased. At 0 kg lime, the NH4-N decrease was slower than at the 3- and 6-kg lime treatments and NO3-N was not found. Similarly treated bark without plants (rooted cuttings of Ilex crenata cv. Convexa) was used to determine NO3-N accumulation rate (NAR). NAR was greatest at 6 kg of lime, except at the last 2 sampling dates, when NAR did not differ between 3 and 6 kg of lime. This lack of difference was attributed to a limiting NH4-N supply at 6 kg of lime. In a second experiment, NAR of bark treated with 6 kg of lime per m3 and fertilized with 300 p.p.m. NH4-N was 3 times greater than with bark treated with 100 p.p.m. NH4-N, thus supporting the contention that, over time, the NH4-N supply of the 100-p.p.m. treatment limited nitrification. The results indicated that the stimulative influence of lime on nitrification is subject to medium pH and NH4-N status that changes over time.

(489) Wright, A. N., A. X. Niemiera, et al. (1999). Preplant lime and micronutrient amendments to pine bark affect growth of seedlings of nine container-grown tree species. HortScience. Alexandria, Va. : The American Society for Horticultural Science. July: 669-673.
The objective of this study was to determine the effects of lime and micronutrient amendments on growth of seedlings of nine container-grown landscape tree species in two pine bark substrates with different pHs. Acer palmatum Thunb. (Japanese maple), Acer saccharum Marsh. (sugar maple), Cercis canadensis L. (redbud), Cornus florida L. (flowering dogwood), Cornus kousa Hance. (kousa dogwood), Koelreuteria paniculata Laxm. (golden-rain tree), Magnolia x soulangiana Soul.-Bod. 'Lennei' (magnolia),

*Nyssa sylvatica Marsh. (blackgum), and Quercus palustris Muenchh. (pin oak) were grown from seed in two pine bark substrates with different pHs (pH 4.7 and 5.1) (Expt. 1). Preplant amendment treatments for each of two pine (Pinus taeda L.) bark sources were: with and without dolomitic limestone (3.6 kg(.)m(-3)) and with and without micronutrients (0.9 kg(.)m(-3)), and with and without micronutrients (0.9 kg(.)m(-3)), supplied as Micromax. Seedlings were harvested 12 and 19 weeks after seeds were planted, and shoot dry weight and tree height were determined. The same experiment was repeated using two of the nine species from Expt. 1 and pine bark substrates at pH 5.1 and 5.8 (Expt. 2). Seedling shoot dry weight and height were measured 11 weeks after planting. For both experiments, pine bark solutions were extracted using the pour-through method and analyzed for Ca, Mg, Fe, Mn, Cu, and Zn. Growth of all species in both experiments was greater in micronutrient-amended than in lime-amended bark. In general, adding micronutrients increased nutrient concentrations in the pine bark solution, while adding lime decreased them. Effect of bark type on growth in Expt. 1 was variable; however, in Expt. 2, growth. was greater in the low pH bark than in the high pH bark. In general, nutrient concentrations in bark solutions were higher in low pH bark than in high pH bark for both experiments. Under the pH conditions of this experiment, micronutrient additions stimulated growth whereas a lime amendment did not. XAU: Virginia Polytechnic Institute and State University, Blacksburg, VA. *LHM: LIB HAS: 'MAIN LIB-6TH FLR SB1 .H83 1966- v.1 -- Currently received (Current issues are held in Main Serials Reading Room). CALL # = SB1 .H83.*

(490) Wisniewski, M. and M. Fuller (1999). Ice nucleation and deep supercooling in plants: new insights using infrared thermography. Cold-Adapted Organisms: Ecology, physiology, enzymology and molecular biology. R. Margesin and F. Schinner. Berlin, Springer-Verlag: 105 - 118.

(491) Evers, P. W., J. Donkers, et al. (1988). Micropropagation of forest trees through tissue culture. Wageningen, Netherlands, Pudoc.
A survey of the work done at the Physiology Department of the Dorschkamp Institute from 1983 to 1986. Individual chapters cover Alnus glutinosa, Salix alba, Pseudotsuga menziesii, Platanus orientalis and P. X acerifolia, Quercus robur, Populus spp. (3 clones each of P. trichocarpa, P. deltoides, P. tremula and P. X euramericana [P. canadensis], and 2 hybrids of P. alba X P. glandulosa), and Ulmus spp. (incl. U. villosa). Methods were developed for 4 organ or tissue types: bud, embryo, meristem and callus. Each chapter includes: introduction; preparation for tissue culture; initial phase of culture; tissue culture phases; adaptation to soil; and (sometimes) gene conservation.

(492) Bychenkova, E. A. and A. David (1978). Callus formation and organogenesis in tissues of leaves of Populus balsamifera L. cultivated in vitro. Soviet Plant Physiology 25(2 pt 1): 216 - 222.
We studied callus formation and organogenesis in tissues of balsam poplar leaves cultivated on Murashige-Skoog, Gautheret' a, and Heiler' a media. Growth stimulants were added to the media in two variants: 1) 2,4-D; and 2) NAA + kinetin. Cultures were incubated in the dark and under light. Intensive callus formation was observed on Murashige-Skoog medium containing 2,4-D, while intensive callus formation and rhizogenesis were recorded on the same medium containing NAA + kinetin, rhizogenesis being observed both on the leaf disk and on the callus here.. On Gautheret's and Heller's media, callus formation was weak on media containing 2,4-D and absent on media containing NAA + kinetin, while rhizogenesis was weaker than on Murashige-Skoog medium. Callus tissue was cultivated in transplant cultures on Murashinge-Skoog, Gautheret's, and Darnan's media containing different concentrations and combinations of auxins and cytokinins. On media containing 2,4-D, only intensive growth of undifferentiated callus tissue was obtained invariably; on media containing NAA + kinetin, only rhizogenesis was obtained; and on media con-taining NAA + BAP, rhizogenesis was obtained on Gautheret's and Murashige-Skoog media, while rhizogenesis or rhizogenesis and bud and shoot formation were obtained on Darzan' a medium. Induced roots and shoots were separated from the callus tissue and cultivated on Murashige- Skoog medium and Gautheret's medium containing special additives. Rooting of induced shoots was obtained on Murashige- Skoog medium.

(493) Wang, S. Y., G. L. Steffens, et al. (1986). Breaking bud dormancy in apple with a plant bioregulator, thidiazuron. Phytochemistry 25(2): 311-317.
The effects of N,phenyl-N'-1,2,3,-thidiszol-5-ylurea (thidiazuron; Dropp; SN49537; TDZ) on metabolic changes in apple buds during dormancy break were determined. The data showed that thidiszuron has the capacity to release lateral buds from dormancy. Decreasing degree of bud break and bud growth with thidiazuron treatment occurred in a basipetal direction, suggesting a gradient of increasingly deep rest from shoot apex to base. The breaking of dormancy by thidiazuron is correlated with increase in DNA, RNA, protein, l,aminocyclopropane-l-carboxylic acid (ACC). l-(malonylamino) cyclopropane-l-carboxylic acid (MACC). S-adenosylmethionine (SAM) as well as with greeter polyamine formation. Polyamine and ethylene biosynthesis did not seem to be competing for SAM, their common substrate, during bud break and bud development. The release of dormancy in apple bud by thidiazuron was inhibited by cordycepine, 5-fluorouracil, 6-methylpurine and cycloheximide. Inhibition of bud break and bud growth also resulted from treatment with a-difluoromethylarginine (DFMA) and s-difluoromethylornithine (DFMO). DFMO was more inhibitory than DFMA.

(494) Hare, P. D., J. v. Staden, et al. (1994). Inhibitory effect of thidiazuron on the activity of cytokinin oxidase isolated from soybean callus. Plant and Cell Physiology 35(8): 1121-1125.
Thidiazuron inhibited activity of cytokinin oxidase from soyabean cv. Acme cotyledonary callus by a mixed, predominantly uncompetitive mechanism. This result is discussed as one of several possible modes of action of phenylurea-type cytokinins, which represent a problem in cytokinin structure-activity relationships.

(495) Hutchinson, M. J., S. J. Murch, et al. (1996). Morphoregulatory role of thidiazuron: evidence of the involvement of endogenous auxin in thidiazuron-induced somatic embryogenesis of geranium (Pelargonium X hortorum Bailey). J. Plant Physiol. 149(5): 573-579.
Thidiazuron-induced somatic embryogenesis in hypocotyl cultures of geranium (Pelargonium X hortorum cv. Scarlet Orbit Improved) consists of an induction phase on medium containing thidiazuron (TDZ) at 10 or 20 µmol/litre followed by an expression phase on a basal medium lacking growth regulators. The induction and development of somatic embryos were found to be closely related to levels of endogenous and exogenous auxin. Inclusion of the auxin-action inhibitor, 2-p-(chlorophenoxy)-2-isobutyric acid (PCIB), and the auxin-transport inhibitor, TIBA, in a TDZ-induction medium decreased embryogenic response of the cultures by different mechanisms. The decrease of the embryogenic response in the presence of PCIB was accompanied by a corresponding decrease in endogenous levels of auxins, cytokinins, and ABA. These changes in the profiles of endogenous plant growth regulators were not evident when TIBA was used. High concentrations of exogenous IAA in the expression medium suppressed the development of somatic embryos. Although the

precise mode of action of TDZ is unknown, it is suggested that TDZ modulates endogenous auxin metabolism during somatic embryo development in geranium hypocotyl cultures.

(496) Visser, C., J. A. Qureshi, et al. (1992). Morphoregulatory role of thidiazuron. Substitution of auxin and cytokinin requirement for the induction of somatic embryogenesis in geranium hypocotyl cultures. Plant Physiology 99(4): 1704-1707.
Somatic embryogenesis was induced in hypocotyl explants of Pelargonium X hortorum cv. Scarlet Orbit Improved cultured on MS medium supplemented with various concentrations of thidiazuron (TDZ). Within 2 weeks, somatic embryos were observed in treatments containing TDZ at 0.2-1.0 µM. The use of BA in combination with IAA also resulted in embryogenesis, but at a significantly lower rate than that obtained with TDZ. Hypocotyl culture for only 2 days on TDZ-supplemented medium before transfer to growth-regulator free medium was sufficient to induce somatic embryogenesis. This distinction between the 'nduction and expression of embryogenesis may provide an experimental system for studying the developmental biology of somatic embryogenesis. Substitution of the auxin-cytokinin requirement by TDZ suggests the possibility of a novel mode of its action by modulation of endogenous growth regulators.

(497) Crisosto, C. H., A. N. Miller, et al. (1990). Effect of fall ethephon applications on bloom delay, flowering, and fruiting of peach and prune. HortScience 25(4): 426-428.
Studies were carried out in Oregon, USA during 1985-87. In plum, cv. Italian Prune, ethephon at 250 and 500 mg/litre applied at 10% leaf-drop stage delayed flowering by 13 and 16 days, respectively. Only a 5- and 7-day flowering delay occurred when it was applied at 50% leaf-drop stage. Fruit set and yield were not reduced in Italian Prune when ethephon was applied at the 50% leaf-drop stage. Early applications, from vegetative maturity to the 10% leaf-drop stage, did not reduce yield in Italian Prune when trees had been previously defoliated with 3.0% urea. Early leaf removal, before vegetative maturity, caused reduction in peach flower and fruit numbers. In several peach cultivars, all the ethephon treatments were detrimental to flower density, fruit set and yield, in spite of flowering delay. The ethephon-treated Italian Prune trees yielded more than the untreated trees in 1987 as a result of frost avoidance through delayed flowering.

(498) Crisosto, C. H., P. B. Lombard, et al. (1989). Fall ethephon delays bloom in 'Redhaven' peach by delaying flower differentiation and development during dormancy. Journal of the American Society for Horticultural Science 114(6): 881-884.
In trials at Corvallis, Oregon, USA, ethephon at 120 mg/litre applied to hand-defoliated or non-defoliated trees in late Oct. 1984 delayed full bloom by about 5 days in 1985. The same treatment applied on 1 Nov. 1985 delayed full bloom by 9 days in 1986. Hand defoliation alone was not effective in delaying bloom in either season. Ethephon treatments increased ABA and ethylene levels in dormant buds collected throughout the 1985-86 dormant season. Starch and reducing sugar contents and total chilling requirement were not affected by ethephon and hand defoliation. Flower primordia were delayed in differentiation and growth during late autumn following a 1986 spray of ethephon. Delay in flower development and growth may be caused by increased levels of ethylene and ABA.

(499) Huang, B. K. (2000). Getting Oriented. American Nurseryman(November 15): 33 - 34.
Properly designed containers can produce quality plants with healthy root systems

(500) Welander, M., E. Jansson, et al. (1989). In vitro propagation of Populus x wilsocarpa - a hybrid of ornamental value. Plant cell, tissue and organ culture 18: 209 - 219.
Populua x wilsocarpa, a hybrid of important ornamental value, cannot be seed--propagated, nor grafted, since a compatible rootstock has not been identified. A micropropa-gation protocol consisting of a series of steps was therefore developed to facilitate the commercial production of this species. The technique involved the transfer of swelling buds a growth initiation medium with the following composition: N6 macronutrients, MS nutrients and vitamins supplemented with 0.5m3 l-' BAP. The best buds were from dormant twigs, stored at 0.-2C and then foreed to burst prior to culture initiation. Shoot multiplication was on a basal WPM medium including 0.1 mgl-1 BAP and 0.001 mgl-1 NAA. Shoot elongation and rooting was also on a basal WPM medium supplemented with 1.0mgl-1 GA3followed by a transfer to a peat-perlite mix in the greenhouse.

(501) Douglas, G. C. (1984). Formation of adventitious buds in stem internodes of Populus spp. cultured in vitro on basal medium: influence of endogenous properties of explants. J. Plant Physiol. 116: 313 - 321.
Stem-internodes of the following poplar species formed adventitious buds when cultured in vivo on basal medium in the absence of exogenous growth regulators: Populus nigra– P. deltoides; P. tacamahaca, P. tricAlocarpa, P. alha. P. wilsonji and Popidus hybrid TT32 (P. trichocaspa x P. tacarnahoca). The number of buds formed per internodal explant varied with each genotype. Adventitious buds differentiated in tissue produced by cambium and phloem cells.

Capacity for bud formation was highest at the physiological apical end of explants. Morpho-genesis was reduced in explants cultured with an axillary bud. Formation of adventitious buds was greatest during the initial period of explant culture; bud-formation was reduced or absent in re-cultured explants. Bud-forming capacity was related to length of explant; explants 2mm in length were unresponsive whereas a mean of eight buds were obtained per 8mm explant. Inter-nodes close to the shoot apex failed to produce buds and morphogenic competence increased with increasing distance from the apex.

(502) Rutledge, C. B. and G. C. Douglas (1988). Culture of meristem tips and micropropagation of 12 commercial clones of poplar in vitro. Physiol. Plant. 72: 367 - 373.
Twelve commercial clones of poplar were cultured in vitro from meristem tips (0.3-0.5 mm diameter), shoot tips (4-6 mm long) and nodal segments (5-10 mm long). Shoot-producing cultures were obtained from 4, 32 and 70% of meristem tips, shoot tips and nodal segments within 12, 6 and 4 weeks, respectively. The genotype of cultures had a greater influence on development of shoot-producing cultures than medium composition. Cultivars MaxIBer and Oxford had the highest rates of estab-lishment in culture and subsequent shoot proliferation, while P. tacamahaca, P. trichocarpa and cv. Robusta exhibited very low rates of establishment and low vigor in vitro. Shoot tip development was best on agar-solidified medium whereas liquid medium resulted in vitrification. Higher rates of axillary shoot production from established cultures were obtained with benzyladenine or zeatin than with 2-isopen-tenyladenine. Reducting the benzyladenine concentration from 4.4 to 1.1 microM, increased the production of elongated shoots suitable for rooting.

(503) Schier, G. A. and R. B. Campbell (1976). Differences among Populus species in ability to form adventitious shoots and roots. Canadian Journal of Forestry Research 6: 253 - 261.
Differences in suckering from root segments and in rooting from sucker cuttings were studied among four species of Populus,

including three poplars, P. angustifolia James, P. delsoides Barrr., and P. balsamif era L., and an aspen, P. tremuloides Michx. Places where suckers originated on root segments were more variable in the poplars than in the aspen. Whereas suckers developed in the aspen only from the periderm, suckers developed in the poplars from the periderm and from cambium exposed at the cut ends of segments and lateral roots. Poplar suckers arising from the periderm originated from preexisting suppressed buds embedded in the periderm. Suckers developed in the aspen from pre-existing primordia. Lateral root formation from preexisting and newly initiated meristems on root segments was common in the poplars but rare in the aspen. The presence of lateral roots increased sucker growth, and the development of suckers and lateral roots responded to the inherent polarity of the root segment. Sucker cuttings from the poplars were generally superior in rooting capacity to those from the aspen.

(504) Tilt, K. (2000). Strategic irrigation. American Nurseryman(August 1, 2000): 30 - 36.
By modernizing irrigation systems, growers can promote container-plant growth, improve production and reduce runoff

(505) Rowland, L. J., E. L. Ogden, et al. (1999). Use of blueberry to study genetic control of chilling requirement and cold hardiness in woody perennials. HortScience 34(7): 1185 - 1191.
We are using a combination of molecular, genetic, and physiological approaches to investigate genetic controls of chilling requirement and cold hardiness in blueberry (Vaccinium section Cyanococcus). In this paper, the term "cold hardiness" specifically refers to flower bud hardiness in the cold-acclimated state. The goals of our research are to: 1) construct a genetic linkage map of blueberry using diploid popula-tions that segregate for chilling requirement and cold hardiness; 2) develop a better understanding of the modes of action of chilling requirement and cold hardiness genes, based on genetic analyses ofgene action and quantitative trait loci (QTL) analyses, and tag genes controlling these traits. Concomitantly, we are trying to identify and isolate chilling/cold-responsive genes from blueberry and determine their relationship to dormancy and/or cold hardiness transitions. Here we describe the system (among blueberry populations) and the strat-egies used in our research, and discuss our progress in the research areas outlined above.

(506) Niemera, A. X. and C. E. Leda (1993). Nitrogen leaching from Osmocote-fertilized pine bark at leaching fractions of 0 to 0.4. Journal of Environmental Horticulture 11(2): 75-77.
Pine-bark filled PVC columns with 1 g Osmocote (14N-6.3P-11.6K)(14-14-14) per column were irrigated 5 days a week for 12 weeks with a leaching fraction (LF) of 0, 0.2 or 0.4. Every two weeks cumulative N content of collected leachate and medium solution N concn (pour-through method) were determined. The total amount of N leached from bark at 0.4 LF was 61% greater than at 0.2 LF. Medium solution NO3-N concn of 0 LF were four to eight times greater than at 0.4 LF for all sampling dates. After 84 days, there was no difference in amount of N remaining in Osmocote prills for the LF treatments. It is concluded that to increase the amount of N available to plants and decrease the amount of N lost by leaching, growers should irrigate with the lowest leaching fraction possible.

(507) Tyler, H. H., S. L. Warren, et al. Reduced leaching fractions improve irrigation use efficiency and nutrient efficacy. Journal of Environmental Horticulture 14(4): 199-204.
An experiment with 2 leaching fractions (LF = volume of water leached / volume of water applied) and 2 fertilizer rates was conducted to evaluate the effects of reduced irrigation volume in combination with reduced fertility on irrigation use efficiency, nutrient efficacy (retention), and plant growth. Rooted cuttings of Cotoneaster dammeri cv. Skogholm were potted into 3.8-litre containers in a pine bark:sand substrate (8:1 by vol). Osmocote 24N-1.7P-5.8K was topdressed at 3.5 or 1.75 g N per container at treatment initiation. The experiment, a RCBD with four replications was conducted for 100 days on a container-grown plant production area subdivided into 16 separate plots that allowed for the collection of all irrigation water leaving each plot. Twenty containers were placed in each plot. Irrigation water was applied daily to attain either a high LF of 0.4-0.6 or a low LF of 0.0-0.2. Irrigation water was applied in 2 cycles with a 2-hour rest interval between each application via pressure compensated spray stakes at a rate of 200 ml/min (0.28 in/min). Volume of effluent from each plot was measured daily and analysed for NO3, NH4 and P. Low LF decreased irrigation volume and effluent volume by 44 and 63%, respectively, compared with high LF. Irrigation use efficiency by plants irrigated with low LF was 29% greater than with high LF. Compared with high LF, low LF decreased cumulative NO3 and NH4 contents in effluent by 66 and 62%, respectively, for containers given 3.5 g N. Low LF also reduced cumulative P content in the effluent by 57% compared with high LF. Shoot and total plant dry weights produced with low LF were reduced by 8 and 10%, respectively, compared with plants grown with high LF. Root dry weight was not affected by LF. Shoot, root, and total plant dry weights with 1.75 g N were reduced by 26, 26 and 28%, respectively compared with those given 3.5 g N. N efficiency was higher when plants were given 3.5 g N regardless of LF. To maximize N absorption and minimize N losses requires a combination of maintaining an adequate N supply and a low LF.

(508) Rathier, T. M. and C. R. Frink Nitrate in runoff water from container grown juniper and Alberta spruce under different irrigation and N fertilization regimes. Journal of Environmental Horticulture 7(1): 32-35.
Juniperus horizontalis cv. Plumosa Compacta Youngstown and Picea glauca cv. Conica were grown for one season in 2.2-litre nursery containers in a potting medium containing composted hardwood bark, sphagnum peat moss and sand (1:1:1 by vol). The containers were placed over lysimeters permitting continuous collection and measurement of water passing through and around the containers. Slow release or soluble N was applied at an annual rate of 1.6 g N/pot. Containers were irrigated by either trickle or overhead methods and water volumes were recorded. Subsamples of leachate were collected and analysed for nitrate. Much less nitrate was leached by the trickle than by the overhead irrigation. Although slow release N sources lost considerably less nitrate in runoff water, there was still sufficient nitrate lost by these sources to pollute groundwater unless annual fertilizer needs were supplied by split applications. Depending on the source, 58-80% of the N applied as slow release fertilizer was not recovered in either the plant or the runoff water.

(509) Purvis, P., C. Chong, et al. Recirculation of nutrients in container nursery production. Nutrient cycling in crop cultural systems 80(1): 39-45.
This study evaluated (a) the capacity of a computerized injector to deliver and recirculate nutrients in a container nursery, and (b) plant growth and nutrient status under this regime compared with non-recirculated methods of fertilization, using Physocarpus opulifolius cv. Dart's Gold potted in 6-L containers filled with a medium of pine bark, peat, and soil (75, 15, and 10%, by volume). The injector was programmed to deliver NH4-N (24 mg L-1), NO3-N (150 mg L-1), P (54 mg L-1), and K (235 mg L-1) and other nutrients, with or without recirculation. Plants grown with recirculated nutrients were placed on aluminium troughs to collect the leachate, which was pumped back to the injector, recharged (based on a target electrical conductivity (EC) value of 1.85 dS m-

1), and returned to the crop. Additional plants were grown on a crushed stone base and fertilized (a) by the computerized injector without recirculation, (b) with water soluble Plant-Prod 20-8-20 (200 mg L-1 N; non-recirculated) delivered through a Dosatron proportioner, or (c) with incorporated, controlled release Nutricote 18-6-8, Type 140 (6.5 kg m-3). NH4-N, NO3-N, P, and K concentrations delivered by the computerized injector (recirculated and non-recirculated; mean over six dates, 3 July to 28 August 1997) were 50, 22, 41, and 39%, respectively, lower than targeted values. Electrical conductivity values were not significantly different from those targeted. The pH values (6.2-6.4) were higher than targeted (6.0). The amounts of N, P, and K used were reduced by between 57 and 77% with recirculation compared to without. Notwithstanding reduced N, P, and K values, plants grew best with recirculated nutrients and least with non-recirculated liquid 20-8-20.

(510) Simms, C. (1996). Food of the Norse gods? Garden London 121(3): 124-125.
The Arctic raspberry, Rubus arcticus, is described for use in the garden, both for its fruits and its ornamental value. It is a low-growing, herbaceous perennial, reaching a height of 25-45 cm and spreading by underground shoots to form dense mats of bright green, trifoliate leaves. For commercial production, a sunny or slightly shaded site, sheltered from the wind, is recommended. Soil type is not critical, although very heavy, poorly drained soils and dry, sandy soils should be avoided. At least 2 cultivars are needed for cross pollination, as the commonly available fruiting cultivars, Anna, Beata, Linda and Sofia, are self-sterile. Flowering takes place mainly in late May/early June and the main harvest time is around mid-July in the UK. By late Oct., plants begin to die back and produce a good show of autumn colour. The cultivar Valentina is best grown as an ornamental groundcover as it crops lightly.

(511) Smith, S. W. (1998). Environmental Irrigation. American Nurseryman 187(3): 42 - 44.
Drip irrigation systems can water plants in the landscape more effectively than other types of irrigation systems and conserve our natural resources. But the systems are intricate, and involve many components. Here's an introduction to the system and how it works.

(512) Ahrens, J. F. (1983). Postemergence grass herbicides for woody ornamentals and Christmas trees. Proceedings of the 37th annual meeting of the Northeastern Weed Science Society 318: 318.
In nursery trials, 0.25-1.5 lb fluazifop-butyl or sethoxydim/ac controlled a number of annual and perennial grasses and volunteer rye selectively in a wide range of evergreen ornamentals including some broadleaved spp. Selectivity was uncertain in actively growing forsythia and some azalea cv. Combinations with oxyfluorfen extended post-em. control to many broadleaved weeds. In Christmas trees, combinations with simazine and/or oryzalin were also effective.

(513) Dellen, J. V. (1997). Softwater stories. American Nurseryman(August 1): 28 - 29.
A controversial magnetic device may be an environmentally sound alternative to salt-based water softeners for irrigation systems

(514) Elliott, B. H. (1972). Conifer production from cuttings. Combined Proceedings, International Plant Propagators' Society 22: 262-263.
Describes the production of container-grown cultivars of Chamaecyparis, Thuja, Juniperus and Taxus in Kent. Rooting was done under mist in the first winter, and the plants were sheltered in winter and uncovered in summer. Plants 3 ft high could be produced in two growing seasons instead of the normal three.

(515) Roller, J. B. (1971). Rooting Juniper softwood cuttings under mist. Combined Proceedings, International Plant Propagators' Society 21: 340-342.
Describes the propagation in Tennessee of 18 Juniperus cultivars from cuttings taken in July-August in time to provide rooted plants by the winter. Mist propagation in nursery beds was more economical than rooting in the greenhouse and was equally effective.

(516) Smith, E. M., G. A. Theil, et al. (1978). An investigation into the cause of conifer damage in nursery storage. Ornamental plants.
Young plants of Taxus media cv. Browni and Thuja occidentalis cv. Globosa, 24-30 inches in diameter, were overwintered from 15 December to 21 April under a polyethylene structure. Various plant spacings and light levels were investigated, as was the presence of certain atmospheric gases. Both species showed foliage damage at close spacing, compared with spacing so that only the branch ends were touching. Such damage was much the same whether or not the plants were also covered by black polyethylene film to exclude light. In no treatments were the ethylene levels higher around the plants than in the outside atmosphere. Levels of CO2 were higher under plastic, but were below the known damaging concentration (2%). Nitrogen oxides and total hydrocarbons were also below threshold levels.-

(517) Whitehead, H. C. M. and K. L. Giles Rapid propagation of poplars by tissue culture methods. New Zealand Journal of Forestry Science 7(1): 40-43.
A description of a rapid and prolific method of producing rooted plants of poplar [Populus spp.] - more than 106 plantlets/yr from one bud - from small explants. This method allows manipulation of the growing medium to assist establishment in difficult areas. It also enables international exchange of material under sterile conditions to be made throughout the year.

(518) Whitehead, H. C. M. and K. L. Giles (1976). Rapid propagation of poplars [Populus] by tissue culture methods. Comb Proc Annu Meet Int Plant Propag Soc 26: 340-343.
A rapid method for the propagation of poplars by tissue culture has been developed. In comparison with conventional practices very large numbers of rooted plants can be rapidly formed from small explants and the potting mix can be manipulated to give establishment advantages to the tree when planting out. The technique also gives a method for the international exchange of poplar material under sterile conditions, to eliminate the danger of disease introduction, in a form that can be quickly bulked up at any time of the year.

(519) Bassuk (2001). A taxing taxon. American Nurseryman(January 1): 30 - 31.
Oaks are difficult to propagate vegetatively, but one stooling method has achieved some success

(520) Taylor, R. D., H. H. Kneen, et al. (1986). Calculating the bottom line for a small container nursery. Am Nurseryman 163(4): 56-60, 62, 64, 66-67.
How much does it really cost to start and operate a container nursery? How much does it cost to produce each salable plant? In this study, our objective was to provide some answers that could help nurserymen make informed decisions about whether to enter, shift to, expand or leave container production.

(521) Jarrell, W. M. (1989). Modeling the nursery. American Nurseryman 169(9): 84-92.

Two computer models are discussed: one is designed to predict the characteristics of potting mixes, the other to predict nutrient availability from slow release fertilizers. The software runs on IBM compatible computers or Macintosh spreadsheets. They are concerned with outdoor production of container plants, but basic principles could apply to field and greenhouse production as well.

(522) Gill, S. A., D. S. Ross, et al. (1994). Starting a nursery enterprise: specializing in shade trees. Fact sheet Coop Ext Serv(661): 8.
This publication provides introductory infor-mation on starting a shade-tree nursery operation in Maryland. In this fact sheet we examine the factors that should be considered when planning a plant nursery for shade trees including site selection, water considerations, basic office and equipment needs, and the advantages and disad-vantages of various growing methods for shade-tree production. Refer to Fact Sheet 660 Starting a Nursery Enterprise: Introduction and Reguationsfor an overview of the nursery business in Maryland and a summary of the main regulations that must be complied with to operate a plant nursery in Maryland.

(523) Baldwin, I. and J. Stanley (1981). What to consider before starting a container nursery. Am Nurseryman 154(2): 13, 38,41 - 44, 46, 48, 50, 52, 54, 56, 60,62,64.
The past 10 years have seen a wide range of nurseries expand tradi-tional field production into container production. A lot of newcomers, often from trades quite distant from nursery stock production, have turned their attention and investment to growing plants in rows of pots.
Some container nurseries, even those designed by experienced nurserymen, have been failures. On the other hand, some of the most profitable and envia-ble units were inspired by people who knew nothing about growing and caring for nursery stock. This article looks at some of the main decisions involved in container production and examines the container nursery trade in the coming decade.

(524) Marchant, B. (1982). Operating an established container nursery Greenleaf Nursery's Texas Div. Am Nurseryman 155(2): 54-69.

(525) Neill, G. B. (1986). Nursery research: a practical approach. Gen Tech Rep RM Rocky Mt For Range Exp Stn U S For Serv(125): 10-11.

(526) Smucker, B. (1988). Thingamabobs: seven inventions from seven growers ease life in the nursery. Am Nurseryman 168(10): 56-58, 60-65.

(527) Heacox, L. (1997). Getting serious about solarization. American Vegetable Grower(April): 20 - 21.

(528) Swanson, B. T. and J. B. Calkins (1995). Herbicides for use on container grown woody species and herbaceous perennials: 1994 - 1995. 1995 Nursery and Landscape Projects and Programs. St. Paul, MN, University of Minnesota: 222 - 236.

(529) Swanson, B. T. and J. B. Calkins (1995). Herbicides for use on container grown woody species and herbaceous perennials: 1994 - 1995. 1994 Nursery and Landscape Projects and Programs. St. Paul, MN, University of Minnesota: 207 - 221.

(530) Swanson, B. B. and J. B. Calkins (1994). Herbicides for use on container grown woody species and herbaceous perennials: 1993 - 1994. 1994 Nursery and Landscape Projects and Programs. St. Paul, Minnesota: 195 - 206.

(531) Hartz, T. K. (1994). A quick test procedure for soil nitrate-nitrogen. Communications in Soil Science and Plant Analysis 25(5-6): 511-515.
A procedure for the extraction and measurement of NO3-N in soil is described. The extracting solution [0.025M Al2(SO4)3] and field-moist soil were measured volumetrically. NO3-N concn was determined using NO3-sensitive colorimetric test strips or NO3-selective electrodes for a range of soil textures, moisture contents and NO3-N concn. The procedure was correlated with conventional analytical methods that use 2N KCl extractants (r2 = 0.94). This test procedure is proposed as an on-farm monitoring technique to improve N management.

(532) Calkins, J. B. and B. T. Swanson (1994). Media incorporation of controlled release fertilizers for container nursery stock production: 1993 - 1994. 1994 Nusery and Landscape Projects and Programs. St. Paul, MN, University of Minnesota: 63 - 69.

(533) Swanson, B. T. and J. B. Calkins (1995). Fertilization of field grown nursery stock. 1995 Nursery and Landscape Projects and Programs. St. Paul, MN, University of Minnesota: 156 - 157.

(534) Cammarata, L. D. and D. F. Hamilton (1980). Designing an overhead irrigation system. American Nurseryman 152(3): 12-13, 104-112.
Factors affecting the design are discussed. Notes are included on water quality, types of sprinkler and their spacing, and automatic control systems.

(535) Green, J. L. (1989). Irrigation water recirculating systems. Ornamentals Northwest Coop Ext Serv Oreg State Univ. Corvallis, Or. : The Service. Jan/Feb 13(1): 3-7.

(536) Furuta, T., T. Mock, et al. (1977). Estimating the water needed for container-grown nursery stock. American Nurseryman 145(8): 68.
Estimates are given of the minimum and maximum monthly water consumption by nursery stock in 1-gal containers spaced at 10 X 10 in. Up to about 23 gal of water/container/year were required. The daily evaporation from a Class A pan placed over fallow soil and evapotranspiration from 21 container-grown plant species and cvs were closely correlated. Placing a plastic disc over the soil surface of the container reduced evapotranspiration by about 26%.

(537) Yeager, T., G. Knox, et al. (1996). Irrigation management strategies. Nursery Management & Production(May): 31 - 32.

(538) Devitt, D. A., R. L. Morris, et al. (1994). Evapotranspiration and growth response of three woody ornamental species placed under varying irrigation regimes. Journal of the American Society for Horticultural Science 119(3): 452-457.
Prosopis alba, Chilopsis linearis var. linearis and Quercus virginiana (nursery seedling selection) planting stock, grown in 3.8-, 18.9- or 56.8-litre containers, were planted outdoors [in Nevada] in 190-litre plastic lysimeters in which weekly hydrologic balances were maintained. Weekly soil water storage changes were measured with a portable hoist-load cell apparatus. Irrigations were applied to maintain leaching fractions (LFs) of +0.25, 0.00 or -0.25 (theoretical) based on the equation irrigation (I) = actual evapotranspiration (ETa)/(1 - LF). Tree height, trunk diameter, canopy volume, leaf area index, total leaf area (Q. virginiana only) and DW were monitored during the experiment or measured at final harvest. Average yearly ETa was significantly influenced by planting size and leaching fraction imposed.

Multiple regressions accounting for the variability in average yearly ETa comprised different growth and water management variables depending on the species. LF, trunk diameter and canopy volume accounted for 92% of the variability in the average yearly ETa of Q. virginiana. Monthly ETa data were also evaluated, with multiple regressions based on data from non-water-deficit trees, such that LF could be ignored. In the case of C. linearis var. linearis, monthly potential ET and trunk diameter accounted for 88% of the variability in the monthly ETa. The results suggest that more efficient irrigation of arid urban landscapes could be achieved if irrigations were scheduled based on such information.

(539) Ponder, H. G. and A. L. Kenworthy (1976). Trickle irrigation of shade trees growing in the nursery: II. Influence on root distribution. Journal of the American Society for Horticultural Science 101(2): 104-107.
Irrigation at 5.7 litres/hour without supplemental water did not alter root system depth. Irrigated sugar maple had more fibrous roots (on a weight basis) and irrigated honey locust had more large roots than check trees. Irrigated pin oak had more fibrous roots and more large roots. Root systems of irrigated and non-irrigated trees were distributed in the same volume of soil.

(540) Hunter, W. J. (1996). Vegetable oils could filter groundwater of nitrogen fertilizers. Nursery Management & Production(July): 25.

(541) Skimina, C. A. and J. Kabashima (1994). Water recycling in container crop production. Recycling and resource conservation: A reference guid for nuresry and landscape industries. C. W. J. Heuser and P. E. Heuser. Harrisburg, PA, Pennsylvania Nurserymen's Association, Inc.: 13 - 20.
Many nurseries have developed water recycling systems in recent years. Some have started recycling water because of water shortages and/or high prices for the water they purchase; others have been ordered to reduce or eliminate any runoff from their nurseries. Whatever the reason, water recycling is one of the methods that has been used successfully to deal with these challenges. This chapter discusses how nurseries can recycle water and some of the important, technical aspects of planning and maintaining a recycling system.

(542) Bartok, J. W., Jr. (1993). Capillary mat irrigation system for container nursery plants. Paper American Society of Agricultural Engineers No. 93-1017: 9 pp.
A capillary mat irrigation system, adaptable to most container sizes and spacings is described. Advantages include reduced labour, less water usage and leaching, low cost and easy installation.

(543) Ponder, H. G., C. H. Gilliam, et al. (1984). Trickle irrigation of field-grown nursery stock based on net evaporation. HortScience 19(2): 304-306.
Gardenia jasminoides and Ilex crenata cv. Compacta were field-grown with 4 irrigation rates based on 0, 25, 50 and 100% replacement of net evaporation from class A pan. Irrigated gardenias were larger than non-irrigated ones. Those grown with 25, 50 or 100% replacement of net evaporation had greater total root growth than non-irrigated plants. Root number, root dry weight and fibrous root number in a 20-cm rootball were generally greater with irrigated plants. I. crenata shoot growth was also similarly greater with irrigation. With both species, irrigation based on 25% replacement of net evaporation resulted in plants similar to those at higher irrigation rates.

(544) Cammarata, L. D. and D. F. Hamilton (1979). Designing irrigation systems for the nursery. H O Purdue Univ Coop Ext Serv. West Lafayette, Ind. : The Service. [1979?](HO-156): 1 - 12.

(545) Welsh, D. F. and J. M. Zajicek (1993). A model for irrigation scheduling in container-grown nursery crops utilizing management allowed deficit (MAD). Journal of Environmental Horticulture 11(3): 115-118.
Plant growth and water use of container-grown Photinia X fraseri plants were studied under varying irrigation regimes. Treatments were based on management allowed deficit (MAD) irrigation (including 0, 5, 10, 25, 50, 75 and 95% MAD), which links evapotranspiration (ET) and plant available moisture in determining irrigation schedules. MAD is the soil moisture deficit at the time of irrigation expressed as a percentage of plant available moisture in the root zone. Plant growth was greatest under 25% MAD irrigation. Plant performance and water use were significantly reduced as moisture deficit levels in the growing medium exceeded 50% under MAD irrigation of 50, 75 and 95%. Plant performance also tended to decrease, but plant water use increased, with lower MAD treatments (i.e. 0, 5 and 10%).

(546) Ponder, H. G. and A. L. Kenworthy (1976). Trickle irrigation of shade trees growing in the nursery: I. Influence on growth. Journal of the American Society for Horticultural Science 101(2): 100-103.
Irrigation treatments consisted of 5.7 litres per hour (2 gal/hr) and no supplemental water on sugar maple (Acer saccharum) and honey locust (Gleditsia triacanthos). For white ash (Fraxinus americana L. cv. Autumn Purple) treatments were not water, 1.4 litres per hour, and 2.8 litres per hour, and for irrigated pin oak (Quercus palustris) 5.7 litres per day at application rates of 5.7, 2.8 and 1.4 litres per hour and application time per day of 1, 2, and 4 hours respectively. In 1973 there was a doubling in increase in diameter of irrigated pin oak, white ash, and sugar maple with the higher flow rate per hour over that of checks. Irrigated honey locust trunk diameter increase was greater than checks. In 1974, 1 hr and 2 hr irrigated pin oak and irrigated white ash again outgrew checks but irrigated honey locust and sugar maple did not. Leaf N and K were the only elements to show consistent changes with all species. Leaf N was lower in 1974 compared to 1973 while K was higher. Trickle irrigation did not promote any consistent significant change in nutrient composition of leaves.

(547) Sneed, R. E. and J. Lee Nursery irrigation. .
Irrigation systems for nursery crops need to be very reliable, durable and provide a high coefficient of uniformity. These systems are being used to irrigate very high cash value crops. Depending on the crops, they may be used during much of the year or for a short period. During the production season uniform moisture conditions need to be main-tained to insure maximum plant growth. With decreasing availability and increasing cost of labour, these systems need to be as automated as possible and reasonably maintenance free. Irrigation systems for nursery and greenhouse crops can be divided into basically three categories which coincide with the three production classifications: propagation, container grown and field plantings.

(548) Fox, M. Container irrigation. GC and HTJ 183(13): 32-34.
Overhead spray irrigation of container-grown trees and shrubs is wasteful of water. If sand is used as a base for sub-irrigation, a level site is required, covered with 500 gauge polythene fastened to a timber framework to hold sand at least 5 cm deep. A matting base should be used on the slope; Lantor 4H has given satisfactory results. Costs for matting were half those of a properly constructed sand bed. If sand or matting systems are used, the amount of slow release fertilizer needed is half that required under spray irrigation.

(549) Bhella, H. S. Tomato response to trickle irrigation and black polyethylene mulch. Journal of the American Society for Horticultural Science 113(4): 543-546.
A 2-year field study with the cv. Sunny was conducted on a fine sandy loam soil near Vincennes, Indiana. Use of trickle irrigation resulted in higher petiole P and B and lower Zn concentrations than using no irrigation. Trickle-irrigated soils had lower NH4-N, NO3-N and K, and higher Mg concentrations than non-irrigated soils. The NH4-N, NO3-N and Mg concentrations were higher in soils mulched with polyethylene than in soils without mulch. The use of trickle irrigation increased plant height whereas polyethylene mulch increased plant spread and dry matter production. Early, late and total yields were improved with all trickle irrigation and polyethylene mulch treatments. Total yields were 66, 70 and 123% greater for plants grown with polyethylene mulch, trickle irrigation and polyethylene mulch plus trickle irrigation, respectively, than in the control plants.

(550) Heiskanen, J. (1995). Irrigation regime affects water and aeration conditions in peat growth medium and the growth of containerized Scots pine seedlings. New Forests 9(3): 181-195.
Containerized Scots pine (Pinus sylvestris) seedlings growing in light Sphagnum peat growth medium in a greenhouse in central Finland were subjected to three irrigation treatments. The seedlings were irrigated by saturating the growth medium with a nutrient solution (i) daily or when (ii) -5 or (iii) -10kPa medium matric potential was achieved. In general, foliar nutrient concentrations of the seedlings were similar for all irrigation treatments. In the wet (daily) irrigation treatment, however, the foliar concentration of N was lower and those of P, Ca, S, Mn and Na were greater than in the other two treatments. In the wet irrigation treatment, height growth was less than that of the other treatments. In this treatment the shoot to root ratio and several other morphological characteristics were also reduced, while the number of root lenticels and seedling mortality were increased compared to the other treatments. Rapid growth was obtained by irrigating at -5 to -10 kPa matric potential. In the wet irrigation treatment, the median matric potential and air filled porosity of the peat medium were -0.4 kPa and 11% respectively, which indicated waterlogging and very suboptimal aeration to the seedlings. The respective values for the irrigations at -5 and -10 kPa were -2.7 to -3.3 kPa and 39 to 43%, which were considered to cover the range from optimum to slightly suboptimum for average water availability and aeration.

(551) Kjelgren, R., C. Spihlman, et al. (1994). Effect of irrigation on crabapple growth and water relations during field production with in-ground fabric containers. Journal of Environmental Horticulture 12(2): 108-111.
Growth and water relations of irrigated and non-irrigated Malus sieboldii var. zumi [M. zumi] produced with and without in-ground fabric containers in a field-nursery setting were investigated. Predawn and midday leaf water potential and midday stomatal conductance were measured periodically through the season, and trunk increment, leaf area, root growth, and osmotic potential were measured in late season. Water potential became more negative and stomatal conductance decreased in non-irrigated treatments during an extended mid-summer drought that resulted in less trunk diameter growth and leaf area. Trees grown in fabric containers, both irrigated and non-irrigated, exhibited no detectable differences in water relations over the season. These trees did have fewer roots and less leaf area than the trees grown without fabric containers, indicating that in-ground fabric containers can limit growth even when irrigated. Non-irrigated trees in fabric containers were nonetheless affected by water stress as they had the least trunk growth and most negative osmotic potential of all treatments. It is suggested that irrigation frequency be increased during production with in-ground fabric containers to avoid water stress.

(552) Beeson, R. C., Jr. (1992). Restricting overhead irrigation to dawn limits growth in container-grown woody ornamentals. HortScience 27(9): 996-999.
Elaeagnus pungens, Ligustrum japonicum, Photinia X fraseri cv. Red Top and Rhododendron cv. Fashion (azalea) growing in 10.4-litre containers were irrigated only at dawn with overhead impact sprinklers or pulse-irrigated 3 or 4 times/day with a drip system. Plant water potential was measured diurnally each week for 24 weeks and growth was measured at the end of the growing season in Dec. Overhead irrigation resulted in less growth of all species than plants maintained near 100% container moisture capacity with pulse irrigation. With the exception of P. fraseri, more growth was associated with significantly lower daily accumulated water stress. Water stress of overhead-irrigated plants was generally not severe enough to cause stomatal closure.

(553) Ross, D. S. (1994). Reducing wate use under nursery and landscape conditions. Recycling and Resource Conservation: A reference guide for nursery and landscape industries. C. W. J. Heuser and P. E. Heuser. Harrisburg, PA, Pennsylvania Nurserymen's Association, Inc.: 21 - 35.
Water is essential to nursery production and landscape maintenance. Irrigation, the process of delivering water to plants, involves moving a quantity of water; using energy; buying, installing and maintaining a piping network; and employing personnel to manage and maintain the system. There are several factors to look at in planning the reduction of water use. A qualified irrigation system designer should be consulted when planning and constructing any irrigation system.

(554) Alexander, A. (1986). Foliar fertilization.
This symposium was organized by the Special Fertilizer Group of Schering Agrochemical Division. It contains 34 papers covering (a) fundamental aspects, (b) foliar fertilization under arid and semi-arid conditions, (c) foliar fertilization under tropical conditions, (d) foliar fertilization in horticulture, and (e) foliar fertilization in cereal cultivation. All of the papers are noticed separately. See Subject Index, Conferences, Foliar Fertilization.

(555) Childs, R. D. (2000). A holistic approach. American Nurseryman(May 1): 26 - 28, 30, 32, 34.
An IPM program can help horticulture professionals safely and effectively monitor and control insect pests of woody ornamentals

(556) Kolbe, W., A. Plughan, et al. (1973). The question of a complete fertilizer applied via the leaves in fruit growing. Mitteilungen des Obstbauversuchsringes des Alten Landes 28(4): 106-110.
A short review of the subject is followed by an account of trials in which apple trees were sprayed after flowering with the complete fertilizer Bayfolan (12-4-6 + minor elements). Cox's Orange Pippin trees receiving 5 l/ha 5 times yielded 52 % higher than untreated trees and the fruit showed less surface pitting. With Cox's and Golden Delicious sprayed 12 times at 6 l/ha the yield increased by 57 % and fruit russeting was reduced. In another trial James Grieve, Cox's, Jonathan and Golden Delicious yielded 23 % higher after this treatment. The increases were attributed to improved fruit set and/or less June drop. Fruit size was little affected.

(557) Conlon, H. P. (1999). Dianthus gratianopolitanus 'Firewitch'. American Nurseryman(December 1): 102.

(558) Brand, M. H. (1999). Small divisions of ornamental grasses

produce the best growth following direct potting. HortScience 34(6): 1126-1128.
Potting of bare-root spring divisions is a simplified approach to ornamental grass production. Large and small divisions of eight common ornamental grasses were directly potted into 7-L nursery containers and grown outdoors for 20 weeks to determine an appropriate division size for each grass. Response to division size was dependent on the grass species. Large divisions of Calamagrostis xacutiflora 'Karl Foerster' (Schrad.) produced twice as many inflorescences as small divisions. At harvest, large divisions of Miscanthus oligostachyus 'Purpurascens' (Stapf.) had twice as many inflorescences and 1.5 times as many tillers as small divisions. However, new tiller production in large divisions was only 50% of that in small division plants. Large divisions of Miscanthus sinensis (Anderss.) cultivars produced more tillers and greater fresh and dry weights than did small divisions, but again, the differences were not proportional to the size difference between the initial divisions. Large divisions of Panicum virgatum (L.) produced 50 more tillers per plant than did small divisions, but plant weight, size, and number of inflorescences were not affected by division size. Plants from large divisions of Pennisetum alupecuroides (L.) Spreng. were 7 cm shorter than small divisions and produced 24% more inflorescences and 27% more tillers, but appeared nutrient and/or water stressed. For most grasses, smaller division size is recommended for direct spring potting.

(559) Million, J. B., J. E. Barrett, et al. (1999). Paclobutrazol distribution following application to two media as determined by bioassay. HortScience 34(6): 1099-1102.
A broccoli (Brassica oleracea var. botrytis L.) seedling bioassay was used to measure paclobutrazol activity and distribution in two growing media following drench or subirrigation applications. The bioassay exhibited a saturation-type response curve for paclobutrazol concentrations up to 1000 microgram(.)L(-1) in solution and 100 microgram(.)L(-1) in the media. The concentration of paclobutrazol required to achieve one-half of the maximum observed bioassay activity was 3-fold as high in bark-based commercial potting medium as in a peat-based medium. Less than 2% of applied paclobutrazol leached out during the drench application despite the collection of up to 50 mL of leachate per 120 mL of the solution (1000 microgram(.)L(-1)) that was applied per 15-cm pot. Immediately following drench application, paclobutrazol concentrations in both media were highest in the uppermost 2.5 cm and decreased downward. By 3 weeks after treatment, drench-applied paclobutrazol had moved into lower depths. Distribution of paclobutrazol was limited to the bottom 2.5 cm of media when applied as a subirrigation soak.

(560) McGiffen, M. E., Jr. and E. J. Ogbuchiekwe (1999). Ethephon increases carotene content and intensifies root color of carrots. HortScience 34(6): 1095-1098.
Poor root color is a recurring problem in carrot (Daucus carota L.) production. Consumers prefer dark orange carrots that are high in carotene. However, unfavorable environmental conditions and certain production practices can lead to light orange roots with low carotene content. Growers sometimes refer to this as "white root." No one has clearly established the causes or curses for this disorder. Several environmental factors are known to affect the color of carrots, but to date there is no practical treatment. High density planting often reduces carotene content. Field studies were conducted in the 1995-96 winter growing seasons to determine if foliar applications of ethephon would improve carrot color, carotene content, and yield. Carotene content and root color increased as the number of applications or the amount of ethephon applied with each application increased. Root weight was not significantly affected.

(561) Dahiya, S. S., S. Narender, et al. (1998). Effect of nitrogen and phosphorus on growth, flowering and yield of marigold (Tagetes erecta L.). Environment and Ecology 16(4): 855-857.
Marigold is an important cut flower crop in India. Greenhouse studies were conducted during 1996-97 to assess the effect of N (0, 80, 160 and 240 ppm) and P (0, 40, 80 and 120 ppm) on growth, flowering and yield of potted African marigolds grown in a sandy loam soil. The number of days to 50% flowering were significantly reduced with increasing N and P rates. The number of flowers/plant, plant height, and number of branches/plant were increased up to 240 ppm N, whereas plant spread decreased beyond 180 ppm N. Beyond 180 ppm N, no beneficial effect was observed on flower yield. Increasing P rates significantly improved the growth parameters and yield of marigold.

(562) Dokoozlian, N. K. (1999). Chilling temperature and duration interact on the budbreak of 'Perlette' grapevine cuttings. HortScience 34(6): 1054-1056.
A factorial experiment examined the interaction between chilling temperature (0, 2.5, 5.0, 7.5, and 10 degrees C) and duration (50, 100, 200, 400, and 800 hours) on the budbreak of 'Perlette' (Vitis vinifera L.) grapevine cuttings. Cuttings stored at 0 degrees C exhibited the most rapid budbreak during the first 30 days after being placed under forcing conditions. After this period, chilling temperature had relatively little influence on cumulative budbreak, with cuttings stored between 0 and 10 degrees C generally exhibiting similar rates of budbreak. In contrast, the slope of the budbreak curves increased, indicating more rapid and uniform budbreak, with increased chilling duration. Significant interactions (P less than or equal to 0.0001) between chilling temperature and duration were found for both the number of days required for 50% budbreak and total observed budbreak. The number of days required for 50% budbreak declined, while total observed budbreak increased, with increased chilling duration. Within the temperature range evaluated, a minimum exposure of 200 hours was required to achieve commercially acceptable levels of budbreak.

(563) Hakam, N., S. Khanizadeh, et al. (2000). Assessing chilling tolerance in roses using chlorophyll fluorescence. HortScience 35(2): 184-186.
Chlorophyll fluorescence (CF) was evaluated as a technique to assess chilling injury of rose leaves (13 genotypes) exposed to low temperatures. In the more susceptible genotypes, variable fluorescence (Fv) decreased dramatically as the temperature was lowered. In the less susceptible genotypes, Fv was more stable and decreased more slowly as temperature fell. Our results suggest that measurement of CF may provide a rapid method to prescreen genotypes for chilling susceptibility.

(564) Smith Jochum, C. and M. L. Albrecht (1988). Transplanting or seeding in raised beds aids field establishment of some Echinacea species. HortScience 23(6): 1004-1005.
In field trials, 3 Echinacea spp. (of medicinal interest and grown as cut flowers) were spring-raised by direct-seeding or transplanting seedlings into raised or flat beds. Plant height, leaf and flower numbers, and root and shoot DW were compared. Transplanting resulted in good establishment for all species, with no difference between bed type. E. angustifolia and E. pallida never emerged when direct-seeded on either bed type. Raised beds enhanced the establishment of direct-seeded E. purpurea. Compared with direct-seeding in flat beds, transplanting in raised or flat beds and direct-seeding in raised beds significantly increased root DW of E. purpurea.

(565) Marquardt, D. (2000). Comparison shopping. American Nurseryman(October 1): 50 - 52, 54, 56, 58 - 59.

Growers need to shop around for media that result in optimal plant growth at minimal cost

(566) Chong, C. and P. Purvis (2000). Searching for nonchemical alternatives to container weed control. Landscape Trades(January): 48.

(567) Chong, C., B. Hamersma, et al. (2000). Rooting shrub cuttings in media amended with biosolids. American Nurseryman(March 15): 68 - 69.

(568) Cunningham, T. W. and R. E. Farmer, Jr. (1984). Seasonal variation in propagability of dormant balsam poplar cuttings. Plant Propagator 30(1): 13-15.
Cuttings were taken in Oct., Nov., Jan., Feb. and April from Populus balsamifera trees of less than 25 yr old and trees over 40 yr old growing at Thunder Bay, Ontario, and rooted in containers in a heated greenhouse with a 16-h photoperiod. Half the cuttings from the first 4 collections were treated for 36 h with 100 p.p.m. IBA. IBA increased % rooting from 41% to 66% for the Oct. collection, but otherwise had no significant effect. Age of source tree also had little effect on rooting, probably because preformed root initials are always present in stems of P. balsamifera. Percent rooting and % bud break after 28 days increased over the collection period as bud dormancy became progressively released. Bud break in Oct. and Nov. collected cuttings was very poor, increasing to 80-82% on av. for Jan. material and 100% for April. Rooting % averaged 76-82% for Jan. material, rising to 83-88% for April.

(569) Schwartz, T. (2001). Using Malus without malice. American Nurseryman(January 1): 32 - 34, 36.
Malus species are among the most popular plants used by homeowners today. New varieties will help keep this classic from getting old.

(570) Khemira, H., T. L. Righetti, et al. (1998). Nitrogen partitioning in apple as affected by timing and tree growth habit. J hortic sci biotech 73(2): 217-223.
Nine year old standard-(Std) 'Topred Delicious' and spur-type 'Redspur Delicious' apple trees (Malus domestica Borkh.) on Malling 7A (M.7A) rootstocks were fertilized with ground-applied ammonium nitrate or foliarly-applied urea depleted in 15N on various dates. The treatments consisted of a ground application in spring (March) (SG), a preharvest ground application in August (PHG), a foliar spray in fall (September) (FF), or a combination of each of the last two treatments with SG (SG/PHG and SG/FF). All trees received a total of 120 g N each with the exception of FF trees, which received half the dose. Labelled N from the SG application was allocated preferentially to the fruit, leaves, shoots, and branches and to a lesser extent to the roots. Leaves on young shoots had higher concentrations of 15N label than those on older shoots or spurs, indicating an increasing dependence of the tree on soil N from spring to summer. The amount of N allocated to above-ground tissues decreased as the season progressed. Very little 15N from the PHG application reached the leaves, fruit, buds, or branches but the roots were heavily labelled and substantial amounts of labelled N were found in the following season's fruit, leaves, and shoots. Losses of fertilizer-15N from the PHG application to fruit removal, leaf fall, and pruning were minimal suggesting a higher utilization efficiency of absorbed N. The percentage of N derived from the FF spray was low in all tissues. However, this treatment resulted in 15N reaching the buds and shoots. Spur-type tree tissues tended to have higher N and 15N concentrations compared with those of Std-type trees. These differences appear to be related to different tree size. These differences suggest that the smaller spur-type trees are more manipulable with N management, and may be more subject to the adverse effects of over-fertilization. The subtle differences in N partitioning between tree types may cause spur-type trees to recycle N more efficiently.

(571) Gainer, B. L. (2000). A clockwork forage. American Nurseryman(May 1): 36 - 38, 40.
Growers discuss which pest are feeding on their crops - and how they fight the feeding frenzy

(572) Khemira, H., T. L. Righetti, et al. (1990). Nitrogen partitioning in apple as affected by timing and tree growth habit. J hortic sci biotech 65(5): 541 - 546.
A single postharvest 5 or 10% urea spray increased N content in 1-year-old bark and wood and in flowers and flower buds of 6-year-old Comice pear trees on Provence quince BA29 pear rootstocks and trained to a multiple leader in an experiment in 1987. In 1988, there was also an increase in N in 1-year-old bark and wood but not in the N content of flower buds and flowers. Fruit set was not significantly increased in either year. Urea labelled with 15N was applied to branches and individual spurs immediately after harvest. When the 15 N-urea was applied to branches, the next season's flower buds had 12% of their N derived from the fertilizer (NFF), but when urea was applied to individual spurs only 8% NFF was detected. Remobilization of labelled N from treated to adjacent spurs resulted in less NFF than would occur if all spurs on the same branch received labelled N. Flower clusters distal and basal to the spurs treated with labelled 15N absorbed considerable amounts of N from the labelled spray. However, harvest analysis of spur leaves and fruits adjacent to and distant from treated spurs and branches revealed that urea was only locally mobilized in the tree. In trees receiving postharvest soil N applications, only 2% NFF was detected in flower buds. It is concluded that pear production can benefit from postharvest urea application to trees, particularly if tree N status is low.

(573) Shim, K. K., J. S. Titus, et al. (1972). The utilization of post-harvest urea sprays by senescing apple leaves. Journal of the American Society for Horticultural Science 97(5): 592 - 596.
Senescing apple leaves in growth chambers absorbed 80% of applied urea in 48 h with greater absorption in light than in darkness. The amount of urea absorbed was paralleled by an increase in the concentration of soluble N and urea N in leaf tissues. The bulk of the increase in soluble N was urea and changes in total soluble N paralleled changes in urea N. During leaf senescence on the tree chlorophyll, total N and protein declined and much of this N was translocated into storage tissues. Trees which received a post-harvest urea spray subsequently produced a significantly greater amount of shoot growth and fruit set than trees receiving no urea or a soil application of urea. The yield was not significantly different between trees receiving a 5% urea spray and those receiving the soil application. However, the efficiency of N utilization by the 5% spray was 4 times as great as that of the soil application.

(574) Oland, K. (1963). Responses of cropping apple trees to post-harvest urea sprays. Nature 198: 1282 - 1283.

(575) Oland, K. (1960). Nitrogen feeding of apple trees by post-harvest urea sprays. Nature 195: 857.

(576) Klein, I. and S. A. Weinbaum (1984). Foliar application of urea to olive: translocation of urea nitrogen as influenced by sink demand and nitrogen deficiency. Journal of the American Society for Horticultural Science 109(3): 356-360.
Export of urea N was quantified after 15N-enriched urea was

applied to leaves of the cv. Mancanillo. Labelled N derived from foliar urea applications to mature trees in October 1982 and March 1983 constituted 4.3% and 23.0%, respectively, of the N composition of flowers at anthesis (May 1983). Labelled N applied to leaves following anthesis was translocated to fruits within 3 days. Export of N from treated leaves was greatly reduced when developing fruits and shoot tips were removed. Pre-loading of leaves with standard urea (before foliar application of labelled urea) increased leaf N by 30% and increased slightly the translocation of labelled urea N to the fruits 2 to 4 weeks later. The N status of small potted Manzanillo plants did not influence subsequent absorption of foliage-applied urea: however, N deficiency reduced translocation of labelled urea N from the treated leaves to new shoots and, to a lesser extent, roots. It is suggested that olive leaves represent storage organs for N and release N in response to the metabolic demands of developing reproductive and vegetative organs.

(577) Klein, I. and S. A. Weinbaum (1985). Foliar application of urea to almond and olive: leaf retention and kinetics of uptake. Journal of Plant Nutrition 8(2): 117-129.
Regression equations relating volume of urea solutions retained on leaves initially and leaf area were developed to assess urea deposition nondestructively and facilitate measurement of urea uptake by leaves of olive (Olea europaea L.) and almond [Prunus dulcis (Mill.) D.A. Webb]. Foliar uptake of urea was slower in olive than it was in almond, but uptake in both species was proportional to the concentration of the urea applied. Foliar uptake of urea was not influenced by previous applications. No phytotoxicity was apparent in almond and olive following single applications of 0.5% w/v urea and 4% (w/v), respectively. Approximately 15 times more urea could be applied per cm2 of an olive leaf than per cm2 of an almond leaf at the threshold of phytotoxicity. Leaf N content in olive was increased 47% with minimal phytotoxicity following 5 successive foliar applications of 2% urea within ten days.

(578) Weinbaum, S. A., I. Klein, et al. (1984). Use of isotopic nitrogen to demonstrate dependence of mature almond trees on annual uptake of soil nitrogen. Journal of Plant Nutrition 7(6): 975-990.
In a study assessing the relationship between timing of fertilizer N applications and the contribution of that N to developing fruit and leaves, nitrogen was applied as 15N-depleted (NH4)2SO4 to mature almond [Prunus dulcis cv. Nonpareil] trees in a commercial orchard. The kinetics of isotopic N accumulation by developing fruit and leaves permitted some discrimination between the 2 principal N pools: the N previously assimilated and stored within the trees, and the N newly absorbed from the soil. Less than 15% of fruit N was contributed by the N applied the previous year in March or June. Thus, despite the occurrence of an endogenous pool of previously assimilated N, the almond appeared to be highly dependent on the annual availability of N from the soil. This concept was supported by the occurrence of incipient N deficiency within 14 months of fertilizer N application, as evidenced by reduced fruit dry weight and total Nifruit. The occurrence of these deficiencies coincided closely in time with the cessation of isotopic N accumulation by developing fruit. These data presumably reflect the rate of N turnover in the almond, the limited N reserve in the coarse-textured soil (Delhi sand) in which the trees were growing, and the heightened potential for N loss (presumably by leaching) associated with this coarse-textured soil.

(579) Fisher, E. G. (1952). The principles underlying foliage applications of urea for nitrogen fertilization of the McIntosh apple. American Society for Horticultural Science 59: 91 - 98.

(580) Cook, J. A. and D. Boynton (1952). Some factors affecting the absorption of urea by McIntosh apple leaves. Proceedings of the Amerian Society for Horticultural Science 59: 82 - 90.

(581) Kang, S. M., K. C. Ko, et al. (1982). Mobilization and metabolism of protein and soluble nitrogen during spring growth of apple trees. Journal of the American Society for Horticultural Science 107(2): 209-213.
The extractable protein in bark tissue of 1-year-old shoots of apple trees, cv. Golden Delicious on M.26 rootstocks, declined sharply during spring growth, while amino acids increased. Extensive protein degradation was first visible at the silver-tip stage of growth. Before this some redistribution of N compounds was indicated by the increase in amino acids while protein content remained unchanged. Total extractable N decreased during spring growth. In vitro activity of an acid endoprotease increased rapidly upon regrowth, but its increase preceded the in vitro decrease in proteins. The autolytic activity, however, did not change in the early growth stage, and protein had already declined by 50% before this activity increased. Two 38 000- and 56 000-dalton polypeptides which were present until mid-April were not detected in extracts of shoots collected in May. The 65% decline in total protein observed by May 10, however, could not be accounted for by the loss of these 2 peptides. It is concluded that the immediate N requirement at the early growth stage (up to silver-tip) is met by the transport of soluble N from the adjacent bark and wood. The large N requirement after the silver-tip stage is then met by massive breakdown of storage proteins.

(582) Price, C. E. and N. H. Anderson (1985). Uptake of chemicals from foliar deposits: effects of plant species and molecular structure. Pesticide Science 16(4): 369-377.
The uptake from foliar deposits of 10 14C-labelled compounds into each of 10 species of field-grown plants was measured 26 h after deposition by combustion of leaf tissue after removal of surface deposits. The compounds, which included eight pesticides, covered a wide range of lipophilicity and each was formulated in the same way; they were applied as droplets with a microsyringe. Uptake varied greatly between the species. All compounds were taken up well into maize and Xanthium pennsylvanicum, whereas relatively little entered the leaves of apple or orange. Uptake into the six other species varied according to the compound. Amongst the eight non-polar com-pounds, no relationship between the rate of uptake and molecular size was discerned, and only in X. pennsylvanicum was uptake related to the partition coefficient and water solubility. Considering all the compounds, weak relationships were observed between molecular cross-sectional area and uptake into four species. The range of the uptake rates (x 130) was small compared with those of octan-1-ol-water partition coefficients (x 1010) and water solublities (x107) shown by the 10 compounds. Pos-sible reasons for the abscence of correlations between the uptake and the molecular properties considered are discussed. The results are consistent with either separate routes of cuticular entry for non-polar and polar compounds, or a common route for both types of compound. The generally poor uptake by apple and orange leaves, which may be related to their thick cuticles, highlights the need to develop special formula-tions to optimise uptake into these species.

(583) Khemira, H., T. L. Righetti, et al. (1999). Distribution of urea-derived nitrogen supplied to apple leaves. HortScience 34(6): 1079-1081.
In 2 trials with Golden Delicious apple trees, urea labelled with 15N was applied to young expanding leaves in spring and to senescing spur leaves in autumn. At the low concentrations used (0.5%, 1% and 2% (w/v)), very little spring-applied 15N was found in tissues other than the treated leaf. Autumn-applied urea-15N, however, was detected in high concentrations in dormant buds and

bark of the spurs to which the treated leaves were attached. Almost no N was exported to neighbouring tissues. The following spring, there was some redistribution of labelled N to adjacent buds. Foliar urea sprays applied immediately after harvest contributed most to bud N; less urea-N was exported to the buds following later autumn applications.

(584) Raese, J. T. (1977). Induction of cold hardiness in apple tree shoots with ethephon, NAA, and growth retardants. Journal of the American Society for Horticultural Science 102(6): 789-792.
In trials with 10-year-old Red Spur Delicious trees growth regulators were applied in early autumn to evaluate their effects of induction of cold hardiness in 2-year-old shoots, as determined by the conductivity test. Mid-October applications of 500 p.p.m. ethephon followed 11 days later by 100 p.p.m. NAA, increased cold hardiness by up to 5 deg C by early November in 1974 and to a lesser extent in 1976. Two annual sprays of daminozide (1500-2000 p.p.m.) in June increased cold hardiness slightly (2 to 3 deg) in late autumn of 1974, 1975 and 1976. However, in 1974 treated trees were no hardier than the controls later in the winter, and fruit set on ethephon-treated trees was severely reduced. In most cases, the combined content of fructose, glucose, sucrose and sorbitol in the 2-year-old wood was slightly higher in treatments that induced cold hardiness in November or December 1974 than in the controls. Techniques are described for screening growth regulators for the induction of cold hardiness and estimating relative cold protection.

(585) Kender, W. J., U. Hartmond, et al. (1999). Fruit abscission and leaf drop in citrus cultivars treated with metsulfuronmethyl. HortTechnology 9(3): 412-416.
Fruits of 11 citrus cultivars were evaluated for their response to the experimental abscission material, metsulfuron-methyl (2 mg/litre), as an aid to mechanical or hand harvest. Cultivars evaluated included Ambersweet, Glen Navel, Hamlin and Valencia oranges, Robinson tangerine, Sunburst tangerine, Murcott and Temple tangors (C. reticulata X C. sinensis), Orlando tangelo (C. reticulata X C. paradisi), Ray Ruby and Marsh grapefruits. Fruits of 6 of the 11 cultivars were effectively loosened by metsulfuron-methyl (Hamlin, Valencia, Orlando, Murcott, Temple and Ray Ruby). Addition of an adjuvant was necessary for abscission activity in fruit and leaves. Trees sprayed with metsulfuron-methyl in combination with an adjuvant (Kinetic) had higher percent cumulative fruit drop, higher internal ethylene, and lower fruit detachment forces (FDF) than trees sprayed with metsulfuron-methyl alone. Sunburst tangerine responded poorly to the abscission material in the presence or absence of Kinetic. Leaf loss was greatest in trees sprayed with metsulfuron-methyl and adjuvant, intermediate in trees sprayed with metsulfuron-methyl alone, and least in control trees. Twig dieback was observed in Valencia and Marsh sprayed with metsulfuron-methyl. The peel of some cultivars had irregular coloration and developed pitted areas after harvest. Although metsulfuron-methyl is an effective abscission agent for mature citrus fruit, further work is needed to more accurately define conditions for its safe and dependable use.

(586) Proebsting, E. L. and H. H. Mills (1969). Effects of growth regulators on fruit bud hardiness in Prunus. HortScience 4(3): 254 - 255.

(587) Mathers, H. (1999). Water-saving strategies. American Nurseryman(April 15): 52 -54, 56 - 58.
Several cultural practices can conserve water in the landscape and assist in the growing fo water-resistant plants

(588) Proebsting, E. L., Jr. and H. H. Mills (1976). Ethephon increases cold hardiness of sweet cherry. Journal of the American Society for Horticultural Science 101(1): 31-33.
Late summer sprays of ethephon increased hardiness of dormant sweet cherry fruit buds, delayed flowering, and improved survival through spring frosts thus increasing yields. Wood hardiness was increased slightly. Autumn defoliation was sometimes hastened. Fruit size was reduced but colour, soluble solids and firmness were not affected.

(589) Coleman, W. K. and E. N. Estabrooks (1992). Enhancement of cold hardiness in apple trees by paclobutrazol, thidiazuron and flurprimidol. Can j plant sci 72(4): 1267-1274.
Two-year-old apple trees (cv. Spur McIntosh on the rootstock MM.106) were treated once during Sep. 1987 and again in Sep. 1988 with paclobutrazol, thidiazuron or flurprimidol, alone or in different combinations. Seasonal changes in electrolytic leakage at test stress temperatures of -15, -25 and -35°C were recorded from Oct. to May. During the 2-year study, there was a well-defined acclimatization phase until early Feb. followed by a deacclimatization phase during Feb.-May. The treatment that produced the greatest increases in apple twig cold hardiness was a mixture of paclobutrazol, thidiazuron and flurprimidol at 200 µg + 100 µg + 200 µg/ml, respectively. In 93% of the test dates, this treatment gave a lower injury value than the control at the -25° stress temperature. The treatments increased the hardiness of apple wood throughout the autumn, winter and spring periods without altering the pattern of seasonal changes in hardiness level. Multivariate analyses indicated that treated shoots were less sensitive than the controls to mild temperatures during the winter period.

(590) Coleman, W. K., E. N. Estabrooks, et al. (1992). Seasonal changes in cold hardiness, sucrose and sorbitol in apple trees treated with plant growth regulators. Journal of Horticultural Science 67(3): 429-435.
In experiments designed to separate the apparent effects of temperature on cold hardiness from those on non-structural carbohydrate content, juvenile trees of apple cv. Spur McIntosh on MM.106 rootstock were treated with 200 µg paclobutrazol + 100 µg thidiazuron + 200 µg flurprimidol/ml on 18 Sep. 1987 and again on 16 Sep. 1988. The 1987 application increased shoot hardiness between Oct. 1987 and Feb. 1988 compared with an untreated control when tested at -25° or -35°C, but had no effect on sucrose or sorbitol contents in the bark or wood during this period. From Feb. to May 1988, shoots of treated trees were hardier than those from controls and they had a higher bark sorbitol content. In 1988/89, growth regulator treatment increased shoot hardiness and increased wood sorbitol contents. Factor analysis indicated that shoot hardiness was more closely related to previous air temperatures than was the non-structural carbohydrate content of bark or wood. It is concluded that temperature has a separate and independent effect on hardiness and on non-structural carbohydrate content and that these effects can be separated experimentally by applying growth regulators.

(591) Coleman, W. K. and E. N. Estabrooks (1985). Chemical modification of cold hardiness in apple trees in Eastern Canada. Can j plant sci 65(4): 969-975.
In conjunction with a brief historical study of probable timing and critical environmental factors associated with winter injury of trees in New Brunswick, the effects of Alar-85 [daminozide] at 0.8% and/or Dupont surfactant WK (0.5%) on seasonal changes in cold hardiness and dormancy intensity of Spur Mac on M.111 rootstocks were evaluated. Winter injury patterns revealed that there was, on average, a severe occurrence once every 6 years. These events appeared to be associated with late winter/early spring shoot damage when the shoots were non-dormant and de-acclimatizing. Both substances applied,alone or in combination

reduced freezing injury although these effects were not consistent from year to year.

(592) Gainer, B. L. (2000). Applicator beware. American Nurseryman(January 15): 70 - 72, 74, 76 - 77.
Identifying the signs and patterns of phytotoxicity can help growers improve their chemical-application process

(593) Anyango, J. J. and B. O. Odhiambo (2000). Controlling crown gall in roses. American Nurseryman(February 15): 116.

(594) Pennisi, S. V. and D. B. McConnell (2000). Made in the shade. American Nurseryman(February 15): 63 - 64.
Researchers select the best shade levels for variegated plant production

(595) Maynard (2000). Taking stock. American Nurseryman(February 15): 36 - 38, 40, 42-43.
Maintaining healthy stock plants helps propagators produce high-quality clones of their best species and cultivars

(596) Beattie, D. J. (2000). Timing is everything. American Nurseryman(February 15): 28 - 30, 32 - 34.
Understanding propagation timing of perennials can help growers get their plants to customers within the desired sales window

(597) Zaczek, J. J., C. W. Heuser, et al. (2000). Shade improves oak and maple rooting. American Nurseryman(January 15): 86, 87 - 88.

(598) Dosmann, M. S. (2000). Tilia mongolica. American Nurseryman(January 15): 126.

(599) Youssefi, F., P. H. Brown, et al. (1999). Regulation of nitrogen uptake at the whole-plant level: a study in almond trees. HortTechnology 9(4): 598-600.
It has been proposed that a pool of amino N, whose size is determined by aboveground N demand, cycles in the plant and regulates soil N uptake by exerting an inhibitory effect at the root level. Several experiments were carried out to study this hypothesis in almond trees [Prunus dulcis (Mill.) D.A. Webb]. Based on the evidence found, there is an association, at the whole tree level, between sap N content and soil N uptake. The data are consistent with the possibility that increased phloem sap amino acids result in decreased uptake of soil N.

(600) Sanchez, C. A. and T. A. Doerge (1999). Using nutrient uptake patterns to develop efficient nitrogen management strategies for vegetables. HortTechnology 9(4): 601-606.
N in a soil that is not immediately taken up by a crop is subject to leaching, denitrification and other mechanisms of loss. N uptake studies identify the total amount of N accumulated by the crop and the period of peak demand. This information can be used to devise management strategies aimed at supplying N preceding anticipated uptake. Split sidedress application, fertigation, and use of controlled release fertilizers (CRN) are all viable options for N management, depending on the crop production scenario and available infrastructure. Soil and plant tissue testing can be useful feedback tools for adjusting N applications for soil contributions of N and unexpected N losses. Efficient irrigation is of paramount importance in achieving efficient N fertilization regardless of management practice.

(601) Hartmond, U., J. D. Whitney, et al. (2000). Seasonal variation in the response of 'Valencia' orange to two abscission compounds. HortScience 35(2): 226-229.
Two field studies were conducted to evaluate the effect of metsulfuron-methyl and 5-chloro-3-methyl-4-nitro-1H-pyrazole (CMN-pyrazole) on abscission of Valencia orange (Citrus sinensis) during the 3-month harvest season. Solutions of metsulfuron-methyl at 0.5, 1 and 2 mg L-1 active ingredient (a.i.) were applied at 10-day intervals beginning on 13 February and ending 18 May 1998. Early in the harvest season, 1 or 2 mg L-1 metsulfuron-methyl significantly reduced fruit detachment force (FDF) 14 days after application. Metsulfuron-methyl was less effective during a 4- to 6-week period following flowering ("less-responsive period"). After this period, metsulfuron-methyl regained the ability to loosen fruit. Applications of 2 mg L-1 a.i. were more effective than 1 mg L-1 in reducing FDF and causing leaf drop, but 0.5 mg L-1 a.i. had little or no effect on FDF. Flowers and leaflets on developing shoots and young fruit completely abscised with 1 and 2 mg L-1 a.i. Defoliation and twig dieback was extensive at all concentrations and spray dates, eliminating metsulfuron-methyl as a commercially viable abscission agent for citrus. In a separate experiment CMN-pyrazole at 50 and 100 mg L-1 a.i. and metsulfuron-methyl at 0.5 mg L-1 a.i. were applied to Valencia trees to determine fruit removal with a trunk shake and catch harvesting system. Application of both abscission materials before and after the "less-responsive period" resulted in a 10-12% increase in fruit removal when compared to control trees. Less than a 35% reduction in FDF was sufficient to significantly increase fruit removal. Only 100 mg L-1 a.i. CMN-pyrazole significantly increased fruit removal when applied during the "less-responsive period.".

(602) McNamara, S. and H. Pellett (2000). Cold hardiness of Phellodendron sachalinense Friedr. Schmidt seedlings increases with age. HortScience 35(2): 304-305.
Seedlings of several landscape tree species frequently experience cold injury at temperatures that are noninjurious to older specimens of the same species. However, there are few published reports quantifying age-related differences in hardiness. In this study, the stem cold hardiness of a mature, 35-year-old female Sakhalin corktree was compared with that of half-sib seedling progeny of different ages. Ten-, 22-, and 34-month-old seedlings were hardy to -4°C on 9 Oct., while the 35-year-old parent withstood -12°C. Ten-month-old seedlings exhibited no further increase in hardiness on 26 Oct., whereas the 34-month-old seedlings and the mature parent were hardy to -16°C. The 22-month-old seedlings were intermediate in hardiness on this date. The 10- and 22-month-old seedlings had died back to the snowline by late January, but the 34-month-old seedlings and the mature tree were uninjured. The corktree seedlings did not attain midwinter hardiness levels comparable to the adult tree until the winter following their fourth season of growth. The absence of flower buds on cold-tolerant 4- and 5-year-old seedlings suggests that physiological maturation is not a prerequisite for full expression of the cold acclimation capability of this species.

(603) Smith, M. W., B. L. Carroll, et al. (2000). Mulch improves pecan tree growth during orchard establishment. HortScience 35(2): 192-195.
In an experiment in Oklahoma in 1996, Giles pecan seedlings were either not mulched or mulched with wood chips arranged in a 1- or 2-m-wide square that was 30 cm deep. Mulch treatments were in factorial combination with N applied at 0.08 or 0.16 kg/tree as either a single application at bud break or as a split application at bud break and 3 weeks later. Tree height was positively related to mulch width each year of the 3-year study, and trunk diameter was positively related to mulch width during the second and third years of the experiment. Leaf P and K concentration during 2 years and leaf N during 1 year of the study were positively related to mulch width. Trees receiving the higher N rate were taller during 2 of 3 years, but leaf N concentration was not affected by N rate. No differences in the parameters measured were observed whether N

was applied as a single or as a split application.

(604) Lovatt, C. J. (1999). Timing citrus and avocado foliar nutrient applications to increase fruit set and size. HortTechnology 9(4): 607-612.
The goal of this research was to identify the role essential nutrients play in the physiology of tree crops, and then to apply the nutrient as a foliar fertilizer to stimulate a specific metabolic process at phenological stages when nutrient demand is high. This approach has proven successful. A single winter prebloom foliar application of nitrogen as low-biuret urea [0.16 kg Nitree (0.35 lb Nitree)] to 30-year-old Washington' navel orange (Citrus sinensis L. Osbeck) trees during flower initiation significantly increased yield and fruit number per tree for each of 3 consecutive years (P less than or equal to 0.05). The number of commercially valuable large-size fruit also increased significantly with yield increases (r(2) = 0.88). Sodium tetraborate applied foliarly to Hass' avocado (Persea americana Mill.) trees at the cauliflower stage of inflorescence development (elongation of inflorescence secondary axes, pollen and ovule development) increased the number of pollen tubes reaching the ovule, ovule viability and cumulative yield (P less than or equal to 0.05). Additional examples are presented.

(605) Rose, M. A. (1999). Nutrient use patterns in woody perennials: implications for increasing fertilizer efficiency in field-grown and landscape ornamentals. HortTechnology 9(4): 613-617.
Timing nutrient application to periods of high nutrient demand could increase nutrient use efficiency and reduce the potential for fertilizer leaching or runoff. However, current recommendations for field nursery and landscape ornamentals (extension publications) suggest fertilizing in late fall and early spring despite research with perennial fruit crops that demonstrates low uptake potential during those times. Research is needed to resolve this apparent conflict. Application rates for woody ornamentals, established in the 1960s and 1970s, also need reexamination in the light of environmental concerns.

(606) Choi, C. Y. and G. Giacomelli (1999). Freeze and frost protection with aqueous foam--field experiments. HortTechnology 9(4): 662-667.
Newly formulated aqueous foam was tested in the field. The foam demonstrated the longevity necessary for practical field use. Soil temperatures beneath an insulation layer of aqueous foam were measured to determine the effectiveness of foam as soil mulch. Leaf temperature within a canopy was monitored to observe the modification of plant leaf temperature, and to evaluate the phytotoxic effects of foam applied directly to the leaf canopy. Leaves were not damaged after being covered with the foam for two weeks. The foam-protected soil was effectively insulated, and the aqueous foam proved to be an effective radiation shield against the cold night sky. Temperature differences as high as 5 degrees C (9 degrees F) were measured between the foam-covered and uncovered copper metal plates, which were used to simulate plant leaves. The foam covered plates were as effective as the aluminum foil covered plates in reducing radiation heat transfer.

(607) Choi, C. Y., W. Zimmt, et al. (1999). Freeze and frost protection with aqueous foam--foam development. HortTechnology 9(4): 654-661.
Aqueous foam was developed to serve as a barrier to conductive, convective, and radiative heat transfer. Through the use of a bulking agent, the physical properties of gelatin-based foam were more stable, adhesive, biodegradable, and long lasting. The phytotoxicity, possible environmental hazard and removal of the foam were also considered. Resistance to freezing-thawing, heating-evaporation, and wind were evaluated. Studies to determine the foam's long-term stability under field weather conditions were completed. The handling and performance characteristics of the foam necessary for development of this application were determined. Factors that affect the physical properties and the utilization of the foam were quantified. These included the proportions of the foam components, the mixing temperature of the prefoam solution, the application temperature, and the rate of foam generation. The newly developed foam might be ideal for freeze and frost protection in agriculture.

(608) Farmer, R. E., Jr. and R. W. Reinholt (1986). Genetic variation in dormancy relations of balsam poplar along a latitudinal transect in northwestern Ontario. Silvae Genetica 35(1): 38-42.
Populus balsamifera clones from 5 populations along a transect from N. Wisconsin, USA, to Hudson's Bay, Canada, were examined in a forcing study. The plants showed unconditional physiological dormancy in autumn, but required a relatively short chilling period to overcome this dormancy. Most of the variation in response to chilling was due to differences between clones within populations. Bud break was promoted by a range of temperatures which were equally effective in terms of response to degree hours.

(609) Germida, J. J. and H. H. Janzen (1993). Factors affecting the oxidation of elemental sulfur in soils. Fertilizer Research 35(1-2): 101-114.
The use of elemental sulfur (S0) to alleviate widespread S deficiencies in agricultural soils is limited by the unpredictability of its oxidation to plant available sulfate. This paper reviews the biological, fertilizer and soil-related factors that control S0 oxidation. Sulfur oxidation in soil is mediated primarily by microorganisms, and thus it is the size, composition and activity of the microbial community which dictate oxidation rates. Because S0 oxidation is a biological process, it is strongly influenced by factors directly affecting microbial activity including soil temperature, water potential, and aeration. In many soils these factors represent the primary constraints to S0 oxidation. Oxidation is also influenced by the effective surface area of the S exposed to microbial activity. The oxidation is favoured by reducing the particle size and abundant populations of heterotrophic bacteria and fungi capable of oxidizing S0, thus the availability of organic substrates from residue additions or root exudates may also affect S oxidation. Previous application of S0 may increase oxidation rates in many soils, presumably by stimulating S0 oxidizing populations. The large number of factors that govern S0 oxidation account for the variability in oxidation rates among soils, climatic regions, and agronomic practices. Many of these factors are subject to agronomic control, however, and it should be possible to devise S fertilizer strategies that exploit the slow release characteristics of S0 to meet crop demands efficiently in a variety of conditions.

(610) Watkinson, J. H. and A. Lee (1994). Kinetics of field oxidation of elemental sulfur in New Zealand pastoral soils and the effects of soil temperature and moisture. Fertil res 37(1): 59-68.
The effectiveness of elemental sulfur (S degrees) as a fertilizer is governed by its rate of microbial oxidation in soil to the sulfate form for absorption by plants. Some 80 field oxidation rate experiments were conducted under grazing throughout New Zealand for one year by measuring the residual S degrees in soil at approximately two-month intervals. The S degrees was applied as particles 75 to 150 micrometer in diameter at the rate of 30 kg ha-1. The simple cubic oxidation rate model (no allowance for temperature or moisture changes) accounted for more than 80% of the variance at nearly 70% of sites. The mean annual soil temperature (10-cm depth) was the most important factor found affecting the mean annual oxidation rate constants, accounting for 38% of the variance through the Arrhenius equation. Other factors, including rainfall, soil moisture, pH and soil groups

accounted for only a further 2% of variance. The factor most likely to account for the balance of variance among the sites is the oxidizing efficiency of the associated microorganisms. The rate constant versus temperature relationship for field oxidation in the five New Zealand climate regions was consistent with mean rate constants of soil groups from a similar set of 47 soils incubated at 25 degrees C and field capacity moisture for 10 weeks or more. Field soils, therefore, had an average moisture for the oxidation rate equivalent to that at field capacity. This would explain the lack of contribution of soil moisture to the variance, and would support the use of the mean annual oxidation rate constant (from the mean annual soil temperature) for calculating the optimum particle size range.

(611) Slaton, N. A., S. Ntamatungiro, et al. (1998). Influence of two elemental sulfur products applied to an alkaline silt loam on rice growth. Research Series Arkansas Agricultural Experiment Station No. 460: 326-329.
A field study was established at the Pine Tree Branch Experiment Station, Colt, Arkansas, during 1997 to evaluate the effects two elemental sulfur (S°) products, wettable S (Ws90, Martin Gas Sales, Inc., Kilgore, Texas) and Tiger 90 (Sunbelt Chemical Co., Atmore, Alabama) on soil pH, rice growth and yield on an alkaline silt loam. Each product was applied at rates of 0, 223, 446, 670, 893 or 1785 lb/acre and mechanically incorporated before sowing rice cv. Drew. By day 34 after application, soil pH was reduced about 0.3 units for each 223 lb/acre of Ws90 application (untreated check pH 7.6). Tiger 90 failed to reduce soil pH below 7.0. Tiger 90 and Ws90 rates increased grain yields by 6 to 46% depending on product and rate. Ws90 resulted in greater yields and total dry matter compared with Tiger 90. It is concluded that acidification of alkaline soils can increase rice growth and yield, but the proper S° source must be selected to fit management needs due to differences in rate of breakdown.

(612) Fare, D. C., C. H. Gilliam, et al. (1996). Cyclic irrigation and media affect container leachate and ageratum growth. Journal of Environmental Horticulture 14(1): 17-21.
Two experiments were conducted with container-grown Ageratum houstonianum cv. Blue Puffs to compare cyclic and continuous irrigations. In experiment 1, leachate volumes were reduced by about 54% with cyclic irrigation treatments (0.4 cm water) applied with either a 30-min or 2-h resting phase compared with continuous irrigation at the same rate. Total N leached was about 47% less with the cyclic treatments than with continuous irrigation. In experiment 2, container leachate volumes and N leached were higher from a pine bark:sand medium, while plants were smaller than from a pine bark:peat medium. Growth index and root distribution were similar with cyclic and continuous irrigation.

(613) Rehab, F. I., A. Wallace, et al. (1979). Effect of acidification of a calcareous soil on yield and mineral composition of three cultivars of cotton grown in a glasshouse. Alexandria Journal of Agricultural Research 27(1): 247-249.
Gossypium hirsutum cv. Acala SJ-2 and G. barbadense cv. Giza 70 and Pima PS-5 were grown for 5 wk in calcareous Chino fine sandy loam soil amended with S to result in various degrees of soil acidification. Acidification to soil pH 5.5 significantly improved vegetative yields of Giza 70 and Pima PS-5 and also of Acala SJ-2 but not significantly. Acidification to soil pH 5.1 decreased vegetative yields for all 3 cv. In addition to P, soil acidification increased leaf conc. of K, Mn, and Si. It decreased leaf conc. of Zn, possibly the result of interactions with both P and Mn. It was thought that Zn deficiency was the cause of yield depression at pH 5.1.

(614) Mkwaila, B. (1992). Sulphur for tea. Quarterly Newsletter Tea Research Foundation of Central Africa No. 107: 4-5.
All tea soils in southern Africa are inherently low in S and sulphate of ammonia is therefore used as the fertilizer source of both S and N. Data are presented on the yields and soil S levels assessed at intervals from a trial started in 1959-60 comparing the effects of S applied at various levels between 0 and 312 kg/ha in the pruning cycle, using different fertilizers (sulphate of ammonia, single super phosphate or flowers of sulphur) and application frequencies. After 17 and 33 years there were no significant differences in yields between treatments. Applied S accumulated only in the 0-60 cm soil layer, and applications of about 20 kg/ha were adequate to maintain soil levels similar to those in virgin soils. Soil S levels of 400 kg/ha did not enhance yields. Tea yellows occurred in the S0 treatments for the first time in 1991, and were accentuated by drought in the following year.

(615) Mahler, R. L. (1986). Evaluation of soil pH manipulation on crop production in northern Idaho. Communications in Soil Science and Plant Analysis 17(9): 905-919.
Heavy applications of ammonium-based N fertilizers on cereal crops have resulted in rapid acidification of once neutral soils in northern Idaho. Lime and elemental S applications were used to manipulate soil pH and evaluate consequent effects on the growth of lentils (Lens culinaris) and winter wheat (Triticum aestivum). Lime applications of 2 200 and 4 400 kg/ha resulted in 22 to 23% and 10 to 28% yield increases of lentils and winter wheat, respectively. Elemental S application rates of 2 200 and 4 400 kg/ha reduced: (1) soil pH in the surface 30 cm of the soil profile, (2) lentil and winter wheat yields, (3) populations of Rhizobium leguminosarum in the soil, and (4) N mineralization rates. Soil pH should be maintained at or above 5.6 for lentils and 5.2 for winter wheat.

(616) Widders, I. E. and J. F. Hancock (1994). Effects of foliar nutrient application on highbush blueberries. Journal of Small Fruit and Viticulture 2(4): 51-62.
In pot experiments, N was applied in foliar sprays of labelled urea (0.8 and 1.6%) or KNO3 (1.25 and 2.50%) to 3-year-old plants of highbush blueberry (Vaccinium corymbosum) cv. Jersey. Leaf absorption was also studied using foliar applications of 10 g KNO3/litre. The foliar sprays had no significant effect on yield or leaf N content. Foliar N application only contributed to a small proportion of leaf N, and even less to shoot N. In field trials over 4 years in SW Michigan, N was applied as a 10:10:10 liquid fertilizer (90% of N as urea and 10% as ammonium hydroxide) once or twice per season to commercial plantings of cultivars Rubel, Bluecrop and Jersey. Leaf N concentrations were above the proposed deficiency levels in all cases. Splitting the N application had no effect on leaf N but did increase fruit yield in the third year. It is concluded that there is little benefit to be gained from foliar N application and that N requirements should be met by soil fertilizer application.

(617) Slaton, N. A., R. J. Norman, et al. (1997). Amendment of alkaline soils with elemental sulfur. Research Series Arkansas Agricultural Experiment Station No. 456: 130-136.
Field observations suggested that soil alkalinity was the common factor among fields suffering from 'postflood rice syndrome', which is thought to be an imbalance of multiple nutrients as a result of reduced availability under alkaline soil pH conditions. Application of 1000 lb/acre of elemental sulfur (S) dust was effective in reducing soil pH by 1.2 to 2.5 units in 210 days in laboratory incubation. Field studies showed similar results. Sulfur products having larger particle size required more time to reduce soil pH due to less exposed surface area and, thus, a lower rate of oxidation. Based on buffer pH curves, application rates of 230-

1000 lb/acre of elemental S dust are required to lower soil pH. Application of 1000 lb/acre of elemental S dust tended to increase grain yield at one of three locations in Arkansas during 1996. Application of 4000 lb/acre of elemental sulfur resulted in stand loss and reduced yields caused by soil salinity. Based on preliminary data, acidification of alkaline soils shows promise for improving rice growth and yield.

(618) **Beverly, R. B. (1986). An empirical model to compare pH response of various soils to acid application. Communications in Soil Science and Plant Analysis 17(7): 775-788.**
A method to quantify the pH responsiveness of various soils was developed. 17 soils of widely differing physical and chemical characteristics were treated with distilled water and 8 concentrations of HCl to apply 0 to 0.67 mmol(H+)/cm3 soil. The resulting titration curves were fitted to equations of the form: pH = B / [1 -EXP (-c-rx)] where: x = mmol (H+)/cm3 soil and B, c and r are fitted parameters. Calculations based on the fitted equations provided a basis for quantitative comparison of the buffer intensity for widely divergent soils. The soils used were expected to bracket the responses of high-pH soils in other locations, so a similar empirical approach should be generally useful to quantitatively compared pH responsiveness of soils.

(619) **Michail, N. N., F. S. Faris, et al. (1995). Improvement of leguminous vegetables production in calcareous soil by addition of some acidifying materials. I. Effects on yield and yield components. Fertil res 43(1/3): 87-91.**
Two field experiments were carried out in two sites of Noubaria Agricultural Research Station Farm. The investigated acidifying materials were sulphur, superphosphate and Phosphorine. The materials were mixed with cowpea seeds just before sowing in a rate 1 kg for seeds required to 1 fed (4200 m2) in the first experiment. Additions were 100, 30 and 1 kg S, P2O5 and Phosphorine/fed, respectively to soils before common bean planting in the second experiment where the two varieties Giza 3 and Giza 6 were put under investigation. The residual effect of the soil additions was investigated using bean as a test crop. The obtained results showed that acidification materials were effective in such soil for seed yields of cowpea and common bean - while the residual effect on bean was unconsiderable. The variety Giza 6 of common bean was significantly superior to Giza 3. The harvesting index was higher by using sulphur or superphosphate than Phosphorine in the case of cowpea while in common bean superphosphate and ?hosphorine were more active in increasing this index than sulphur. Acidification process resulted in some increases in harvest index of bean regardless the used material. As for 100 seed weight, it was raised in significant level by using sulphur or superphosphate than Phosphorine or control in the case of cowpea while all treatments were statistically equal in the case of common bean and bean.

(620) **Boswell, C. C., B. Swanney, et al. (1996). The effects of different manufacturing techniques on the availability of sulfate to pasture from mixtures of elemental sulfur with either triple superphosphate or partially acidulated reactive phosphate rock. Fertilizer Research 44(3): 255-263.**
Six different preparations of elemental sulfur incorporated into triple superphosphate, and a single mixture of elemental sulfur with partially acidulated reactive phosphate rock, were evaluated for the rate of release of sulfate-sulfur to a Lolium perenne/Cynosurus cristatus/Trifolium repens pasture on a Warepa soil (Aeric Fragiaquept, fine, silty, mixed, mesic) at Invermay Agricultural Centre, and to an even stand of 2-year-old Medicago sativa on a Streamlands soil (typic laminar pallic) at Omarama, New Zealand. The method of preparing the mixtures affected the size of sulfur particles released on dispersion of fertilizer granules and the rates of release of sulfate from oxidation of the elemental sulfur were controlled by the fineness of the elemental sulfur particles. A mixture prepared by sintering elemental sulfur with mature triple superphosphate was the most effective for a rapid release of sulfate by oxidation and it contained sulfur particles of diameter _75 µm. The mixtures which comprised synthetic blends of elemental sulfur of particle size _150 µm or 150-250 µm, each with mature triple superphosphate, released sulfate at a progressively slower rate than that with particles _75 µm. However, both proved effective fertilizers, releasing sulfate over a 1-2 year period. In contrast, mixtures prepared by adding molten elemental sulfur during the process of manufacturing triple superphosphate, resulted in a coarser distribution of sulfur particles and a slow release of sulfate to plants. The incorporation of sulfur into a mixture with partially acidulated reactive phosphate rock was made via the dispersion of molten sulfur into phosphoric acid which was then used to partially acidulate phosphate rock. The resultant sulfur particles ranged from finely divided (e.g. 38% <150 µm) to moderately fine (81% <500 µm), and the release of sulfate was predictable based on the particle size distribution. Differences between the 2 experimental sites in uptake of plant sulfate reflected the different pastures grown. At the cool temperate coastal site, the L. perenne/Trifolium repens pasture rapidly took up sulfate as it was released into the topsoil. Inland, in the summer-dry environment, the uptake of released sulfate by the deep-rooted M. sativa pasture was delayed for 12-18 months, indicating that the sulfate uptake increased after the nutrient had leached beyond the surface soil layer.

(621) **Iles, J. K. and N. H. Agnew (1993). Responses of five container-grown herbaceous perennial species at laboratory freezing. HortTechnology 3(2): 192-194.**
Containerized plants of Gaillardia X grandiflora [G. aristata], Physostegia virginiana cv. Summer Snow, Salvia X superba cv. Stratford Blue, Tanacetum coccineum cv. Robinsons Mix and Veronica repens were placed in a freezer at 2±2°C on 13 Dec. After a few weeks, plants were subjected to temperatures from 0 to -18°, reached by lowering the freezer temperature by 2°/h. Control plants remained at 2°. Plants remained at treatment temperatures until the temperature of the growing medium had stabilized. After treatment, plants were returned to 2° to thaw gradually, then transferred to a greenhouse at 21°. Following exposure to -10°, survival percentage was 88% for T. coccineum and 100% for the other species; below this temperature, survival percentages generally decreased, although P. virginiana showed 100% survival at -16°. Except for G. grandiflora, plants sustained no significant injury when exposed to -10°. Regrowth DW was poor in all species following exposure to -12°, although the degree of injury varied. Identification of the overwintering organs responsible for the perennial nature of these species will help to clarify how they withstand freezing temperatures.

(622) **Taylor, R. D., E. M. Smith, et al. (1990). Physical facilities and capital requirements for establishing a three-acre perennial container nursery in Ohio--1989. Spec Circ Ohio Agric Res Dev Cent(135): 1-8.**
Capital requirements for establishing a perennial container nursery in Ohio were about $325 000 for a three-acre facility. This facility had 1.2 acres of growing space while buildings, roads, parking area, and other production facilities accounted for 1.8 acres. Of the total capital requirements, about $37 000 (12%) was for bare land, $32 000 (10%) for land improvements, $158 000 (49%) for buildings, and $98 000 (30%) for machinery and equipment.

(623) **Taylor, R. D., E. M. Smith, et al. (1990). Production costs of operating a three-acre perennial container nursery in Ohio--**

1989. Spec Circ Ohio Agric Res Dev Cent(135): 9-13.
Annual production costs of operating a three-acre perennial container nursery in Ohio were determined by synthesizing a model perennial container nursery using the conceptual framework of economic engineering. Annual production costs were about $354 000 for the three-acre facility. Of the total, approximately $172 000 (49%) were fixed costs and $182 000 (51%) variable costs. The model nursery had capacity for annually producing approximately 180 000 (15 000 flats) saleable perennial plants in quart containers, 16 000 saleable chrysanthemums in three-quart containers, and 96 000 (6000 flats) saleable herbs in 16 flats.

(624) Taylor, R. D., E. M. Smith, et al. (1990). Comparative costs of producing alternative plants in a three-acre perennial container nursery in Ohio--1989. Spec Circ Ohio Agric Res Dev Cent(135): 14-17.
The costs of producing container grown perennial plants in Ohio are compared, differentiated by plant group. Total annual costs per saleable plant in a three-acre perennial container nursery by plant group were $1.17 per quart container (4 inches X 4 inches X 4 3/4 inches) for perennials propagated from seed, £1.24 per quart container for perennials propagated from cuttings, £1.49 per quart container for perennials propagated from crown divisions, $1.95 per three-quart container for chrysanthemums, and $0.99 per cell (16 cell/flat) for herbs, and averaged $1.21 for all species. Fixed costs averaged 49% and variable costs 51% of the total.

(625) Glattstein, J. (1990). Dividing perennial grass. Org Gard 37(4): 32-33.

(626) Elkiey, T., M. Haikel, et al. (1987). Application of growth regulators for the adaptation of some perennial plants to container production. Gartenbauwissenschaft 52(5): 210-213.
Bougainvillea glabra, Lantana camara and Hydrangea macrophylla plants sprayed with 1000 and 2000 p.p.m. GA3 produced longer shoots, resulting in taller plants, and a reduction in the number of branches. Chlormequat (CCC) at 2000 and 4000 p.p.m. following GA3 applications prevented excessive plant height, resulted in growth which was in proportion to the size of the container and improved quality. Hydrangea treated with GA3 or with CCC alone showed phytotoxicity symptoms and chlorotic growth. The application of CCC or ancymidol (2000 or 4000 p.p.m. each) increased branching but restricted the height of Hibiscus rosa-sinensis, Fuchsia speciosa and Euphorbia pulcherrima. Ancymidol was more effective than CCC in reducing plant growth. Ancymidol and CCC reduced height and bract size of poinsettias, but had no effect on quality.

(627) Aderhold, A. and J. Kuhn (1991). Scabiosa caucasica - a profitable cut-flower perennial. Gartenbau Magazin 38(10): 48-49.
From trials conducted in Berlin, recommendations are made for the field cultivation of S. caucasica. Plants should be divided in Apr. or mid-Aug. and planted in deep, rich soil of pH 6.4-6.8. Basal and supplementary doses of fertilizer should be given, and the plants should be watered in dry weather but not allowed to become waterlogged. The flowers can be harvested 2-3 times/week between mid-June and late Oct. and yields of 50-60 stems/plant can be expected by the third year. The harvest should not begin until 10-12 weeks after planting out. Good cultivars are Blausiegel, Clive Greewes and Miss Willmott.

(628) Chen, J. J., Y. W. Su, et al. (1999). Use of cold water for irrigation reduces stem elongation of plug-grown tomato and cabbage seedlings. HortScience 34(5): 852-854.
Seedlings of tomato (Lycopersicon esculentum Mill.) and cabbage (Brassica oleracea L. var. Capitata) were planted in 240-cell plug trays in the greenhouse and subjected to irrigation with water at different temperatures once a day. Irrigation with cold (5 to 15 degrees C) water reduced stem length of tomato by 28% to 32% in comparison with irrigation with water at room temperature (27.5 to 30.5 degrees C). Use of water at 10 degrees C did not affect total shoot dry weight but increased the shoot dry weight per centimeter of stem. Irrigation with water at 5 degrees C reduced stem length of cabbage seedlings 40%, but use of water at 10 and 15 degrees C did not. Both shoot and root dry weights were increased by irrigation with water at 10 degrees C. These results demonstrate that irrigation with cold water provides an effective method for improving the quality of plug-grown seedlings.

(629) Dellen, J. V. (1999). The buck stops here. American Nurseyman(March 1): 24 - 26, 28.
Several control strategies are available to help nursery professionals keep unwanted deer away from valuable ornamentals

(630) Wilson, S. B., Rajapakse, et al. (2000). Media composition and light affect storability and post-storage recovery of micropropagated hosta plantlets. HortScience 35(6): 1159 - 1162.
Hosta (Hosta tokudama Makeawa 'Newberry Gold') plantlets were micro. propagated photoautotrophically (without sucrose in medium) or photomixotrophically (with 2% sucrose in medium) for 3 weeks at 23°C under 80 micromol m^{-2} s^{-1} photosynthetic photon flux (PPF) prior to long-term storage. Plantlets were stored for 4, 8, or 12 weeks at 5, 10, or 22°C in darkness or under white (400 - 800nm), blue (400 - 500 urn), or red (600 - 700 urn) light at or near light compensation points. Illumination during storage was necessary to maintain dry weight and regrowth potentials of plantlets in vitro, but light quality had no effect on these parameters. All photoautotrophic plantlets stored in darkness were of poor quality at the time of removal from storage and died when transferred to the greenhouse. Dark-stored photomixotrophic plantlets survived storage for 12 weeks at 5°C, but declined in appearance (visual quality) as the storage duration increased.Decline in visual quality was greaterwhen plantletswerestored at 10 and 22°C. Leaf dry weight of illuminated plantlets increased and percentage of leaf yellowing decreased as storage temperature increased. Recovery of illuminated plantlets from photomixotrophic storage was best when plantlets were stored at 22°C. These plantlets were characterized by increased visual quality (color and form) and increased dry weight compared with those in other treatments. After 60 days in the greenhouse, the dry weight of these plantlets was similar for 4-, 8-, and 12-week storage durations, indicating flexibility in storage time if specific light and temperature provisions are met.

(631) Heims (1999). Heuchera heyday. American Nurseryman(March 1): 30 - 32, 34.
With wonderful flowers, amazing foliage, and good disease and insect resistance, new breed of Heuchera are valuable landscape assets

(632) Klett, J. (1999). Needs for plant materials in the Rocky Mountain region and the Plant Select program. Landscape Plant News 10(1): 5 - 11.
The Plant Evaluation and Introduction Program, hereafter referred to as Plant Select, is a cooperative effort between Denver Botanic Gardens (DBG), Colorado State University (CSU), and members of the Green Industry (signed cooperators) with the following purpose:
1. To increase the diversity (genera, species, cultivars) of commercially available plants better suited for the Rocky Mountain Region and beyond. 2. To fulfill the objectives of Denver Botanic Gardens and Colorado State University as educational,

research, extension and public service institutions. Each of these institutions is professional in nature and oriented toward serving the areas of greatest societal need with emphasis on state and regional priorities and then beyond.

(633) Armitage, A. M. (1996). Forcing of perennials in the greenhouse: A guide to putting flowers and buds on perennials (based on research at UGA). 1999.
Perennials have undergone a major expansion in North America and sales have significantly increased in the last 10 years. The classical nursery grower of perennials produced crops in large containers outdoors which were overwintered for spring sales. Plants were often sold green and the presence of flowers was welcome, but not necessary. The market for perennials has expanded to include sales of non cooled plants in the fall, non cooled plants in the spring, and cooled plants in the spring in smaller containers for gardeners and landscapers. In general, the growing of perennials has been done by the nursery person while the greenhouse operator has concentrated on producing "color plants".

Times are a-changing! The renewed interest in perennials by the garden and landscape public has finally provided the greenhouse operator the kick in the pants he needed to look more closely at perennials. The greenhouse industry was so busy growing a better petunia that they overlooked the beauty of the columbine and the romance of the forget-me-not. However, the difficulty for the greenhouse person was multifold. First, compared with annuals, the number of potential species is overwhelming. Every new book on perennials and every talk on perennials offers more potential plants than the bedding plant or pot plant grower ever dreamed about.

(634) Anon. (1999). Algae control in ponds. Lethbridge, AB, Alberta Agriculture, Food and Rural Development: 3.
Fish farmers face a difficult challenge in maintaining a healthy balance among the water, fish and microscopic flora and fauna in their pond systems. Algae are one important component of the natural nutrient cycles in ponds, but in high numbers, algae can create problems. On the positive side, important chemical changes and metabolic activities in the water are made possible through the release of oxygen and removal of carbon dioxide by algae during photosynthesis.

(635) Iversen, R. R. (1994). Forcing perennial plants: a flower show guide. Public gard 9(4): 30-32.

(636) Ward, D. and R. P. Marini (1999). Growth and development of young apple fruits following applications of ethephon plus carbaryl for thinning. HortScience 34(6): 1057-1059.
In three experiments, apple trees (Malus xdomestica Borkh.) were sprayed, when fruits were 20 to 30 mm in diameter, with a combination of ethephon (800 mg(.)L(-1)) and carbaryl (600 mg(.)L(-1)) to induce abscission of all fruits on the tree. Two days after treatment (DAT), most treated fruits stopped or slowed increasing in diameter, fruit water potential was less negative, and starch accumulation was less than for nontreated fruits. Cellulase activity appeared in the abscission zone by 4 DAT. Fruit growth cessation following treatment was probably due to inadequate assimilate supplied to the fruit, but assimilate flow slowed before cellulase activity was apparent in the abscission zone.

(637) Taylor, R. D. (1990). Requirements and costs of establishing and operating a three-acre herbaceous perennial container nursery. Wooster, Ohio, The Ohio State University, Ohio Agricultural Research and Development Center, [1990] iii, 29 p. :
ill.
This study identifies the resources and costs associated with a herbaceous 3-acre perennial nursery based on practices in USDA Plant Hardiness Zones 5-6 in the north central region of the USA and specific information from Ohio. Calculations were based on 1989 prices. Five groups of container-grown plants, differentiated by cultural requirements were delineated. Grouping was based on the combination of method of propagation with length of production cycle. Group I plants are seed-propagated, Group II plants are cutting propagated, Group III plants are propagated from crown divisions, Group IV: garden chrysanthemums, from purchased rooted cuttings, Group V: herbs, seed-propagated or cutting propagated. Total costs per saleable plant in one-quart containers were: $1.17 for group I plants, $1.24 for group II plants and $1.49 for group III plants. For chrysanthemums, in three-quart containers, these costs were $1. Fixed costs as a percentage of total plant costs were: 51%, 48%, 39%, 44%, and 54% for the 5 groups, respectively. For all groups they averaged 49%. Cost differences among groups were caused primarily by cost of propagation materials, space and overwintering requirements, and length of the production cycle.

(638) Kirven, D. M. (1986). An industry viewpoint: horticultural testing - is our language confusing. HortScience 21(2): 215 - 217.

(639) Markus, D. K. (1986). Spurway/acid extraction procedures. HortScience 21(2): 217-222.

(640) Warncke, D. D. (1986). Analyzing greenhouse growth media by the saturation extraction method. HortScience 21(2): 223-225.

(641) Nelson, P. V. and W. R. Faber (1986). Bulk solution displacement. HortScience 21(2): 225-227.

(642) Wright, R. D. (1986). The pour-through nutrient extraction procedure. HortScience 21(2): 227-229.

(643) Bunt, A. C. (1986). Problems in the analysis of organic and lightweight potting substrates. HortScience 21(2): 229-231.

(644) Niemiera, A. X., T. E. Bilderback, et al. (1994). Pine bark physical characteristics influence pour-through nitrogen concentrations. HortScience 29(7): 789-791.
Pine bark (PB), either unamended or amended with sand (S) at 9 PB:1 S or 5 PB:1 S (v/v), was fertilized with solutions of 100, 200, or 300 mg N/liter solution and tested for N concentration using the pour-through method (PT). PB, 9 PB: 1 S, and 5 PB: 1 S had porosities of 84%, 75%, and 66%, respectively. PT NO3-N concentrations, obtained via PT, of the 5 PB:1 S substrate were 43%, 28%, and 15% higher then PB NO3-N values for the 100, 200, and 300 mg.liter-1 treatments, respectively. Differences in N concentration obtained with PT can be attributed to substrate physical characteristics. Based on the results, data for PT should be interpreted with regard to substrate porosity.

(645) Wright, R. D. and A. X. Niemiera (1987). Nutrition of container-grown woody nursery crops. Horticultural Reviews 9: 75-101.

(646) Ogden, R. J., F. A. Pokorny, et al. (1987). Elemental status of pine bark-based potting media. Horticultural Reviews 9: 103-131.

(647) Bilderback, T. E., S. L. Warren, et al. (1999). Managing irrigation by electrical conductivity. International symposium on growing media and hydroponics, Windsor, Ontario, Canada, 19 26

May 1997 No. 481: 403-408. -
In the nursery industry, controlled release fertilizers (CRF) are a common method of supplying nutrients for container grown crops. However, nutrient solution concentrations in containers and product longevity are directly related to irrigation practices. Daily leaching of containers with high irrigation volume can shorten CRF longevity. When low conductivity readings from container leachates are compared to laboratory nutrient analyses, solution levels are also deficient. The hypothesis of this study was that adjusting weekly irrigation volume based on electrical conductivity could reduce excess and deficient nutrient levels in the container solution and improve controlled release fertilizer longevity. The experiment was conducted on Cotoneaster dammeri cv. Skogholm liners in 308-litre containers. A CRF (15-9-11 Osmocote Plus) was incorporated at 5.0, 4.25, 3.5, 2.75 or 2.0 g N per container. Irrigation was two daily cyclic applications for a total of 800 ml per container. Irrigation volume was reduced after 10 DAI by 30% and was maintained 15-30% lower than the initial 800 ml irrigation volume throughout the study. Irrigation volume was not reduced below 400 ml since previous studies had indicated cotoneaster growth was limited below this volume. Precipitation events reduced the influence of manipulation of irrigation volume on container EC levels. Approximately 107 cm (30 in) of rainfall was received from 30 May until 29 October which was equivalent to 30 days of irrigation. Electrical conductivity was lower than target EC of 0.85 dS/m for all fertilizer application rates for the entire study. EC reading were generally similar for all fertilizer rates. The highest EC reading during the study was 0.6 dS/m. Shoot growth increased with increasing N rate at 89 DAI and 152 DAI and root dry weight increased with increasing N rate at 89 DAI. At 152 DAI all nutrient concentration decreased as fertilizer rate decreased. Foliar N levels for _ 3.5 g N per container dropped below suggested levels. Plant growth and foliar nutrient levels in this study under conditions of frequent and occasionally heavy rainfall show that the 4.25 or 5.0 g N/container applications were required to maximize growth but EC levels never reached those expected.

(648) Zilkah, S., I. Klein, et al. (1987). Translocation of foliar-applied urea 15N to reproductive and vegetative sinks of avocado and its effect on initial fruit set. Journal for the American Society of Horticulture Science 112(6): 1061-1065.
Translocation of 15N was evaluated in the cultivars Fuerte and Hass during inflorescence development and the early stages of fruit set. Urea (2%) increased the number and total DW of the lateral inflorescence per shoot. The concentration of 15N in inflorescences increased in proportion to the concentration of urea applied to the 1-year-old leaves. The amount of 15N translocated was not affected by the proximity of the source leaf to the terminal inflorescence. 15N was translocated to developing fruit and to new (1-month-old) sprouting leaves in similar amounts. Urea N was translocated basipetally from current flush leaves to developing fruits. Removing the vegetative sink reduced N influx to the reproductive tissue and increased initial fruit set by factors of 1.7 and 2.1 in urea-treated and -untreated shoots, respectively. These data indicate that shoot growth does not limit fruit set in avocado through competition for N.

(649) Beaudry, R. M. and S. J. Kays (1988). Application of ethylene-releasing compounds in agriculture. Plant Growth and Leaf-Applied Chemicals. P. M. Neumann, CFC Press: 127 - 155.
Notes are given on absorbed ethylene and ethylene-releasing and -inducing compounds. Ethylene-releasing compounds are reviewed with respect to plant responses including abscission, growth effects, flowering, maturation, ripening and latex production, plant and chemical factors affecting efficacy and penetration, translocation, decomposition and metabolism. Future prospects of ethylene-releasing compounds in agriculture are discussed.

(650) Crisosto, C. H., L. Cid S, et al. (1989). Effect of ethephon application on bud and stem hardiness and bloom delay of 'Redhaven' peach trees. Adv Hortic Sci 3(1): 21-23.
Delaying bloom is of advantage in reducing frost risk and improving pollination. Autumn application of ethephon at 150 mg/litre at the 10, 50 and 100% leaf drop stages delayed bloom by 8, 5, and 3 days, respectively, in 1987. At the 10% leaf drop stage, ethephon reduced flower and hence fruit numbers by almost half compared with trees untreated or treated with ethephon at the 50 and 100% leaf drop stages. Fruit set was not affected by any of the ethephon treatments. Hardiness measured as percentage of bud survival was greater through the dormancy period following treatment at 50% but not at 10% leaf drop.

(651) Rodney, D. R. (1952). The entrance of nitrogen compounds through the epidermis of apple leaves. Proc. Am. Soc. Hort. Sci. 59: 99 - 102.

(652) O'Kennedy, B. T., M. J. Hennerty, et al. (1975). The effects of autumn foliar urea sprays on storage forms of nitrogen extracted from bark and wood of apple shoots. Journal Horticultural Science 50(4): 331 - 338.
Following the application of urea sprays in October on Golden Delicious apple trees, increased amounts of nitrogen were translocated from the leaves into storage tissues. Trees receiving 10% urea spray had significantly higher levels of total nitrogen in bark in both January and February than either those receiving soil application or control treatments. However, there was also a significant increase in total nitrogen in bark from January to February in the sprayed trees, due mainly to an increase in protein nitrogen in January. In February the soluble nitrogen increased while the protein remained constant. There were no significant differences between treatments in wood total nitrogen levels in January. In February the trees receiving the 10% urea spray had significantly higher total nitrogen levels than those receiving either the soil application or control treatments. In the sprayed trees there was an increase in wood total nitrogen from January to February due to an increase in soluble nitrogen, suggesting a redistribution effect.

(653) Swietlik, D. and M. Faust (1984). Foliar nutrition of fruit crops. Horticulture Reviews 6: 287 - 355.
The following are discussed: (a) uptake of foliar-applied nutrients, (b) factors affecting absorption of foliar-applied nutrients, (c) metabolism of foliar-absorbed nitrogen, (d) translocation of foliar-absorbed nutrients, (e) effect of foliar sprays on photosynthesis, stomatal conductance, and transpiration, (f) effect of foliar sprays on horticultural characteristics, (g) technology and general recommendations for foliar nutrient application, (h) commercially available foliar fertilizers.

(654) Bale, S. (1988). An annual or a perennial. HO Univ Ky Coll Agr Coop Ext Serv(65): 19.

(655) Beattie, D. J. (1986). Profiting from perennials: how to start a perennial business. Am Nurseryman 164(9): 81-82, 86-92, 94-98, 100-102.

(656) Fenwick, H. S. (1971). Perennial ornamental plants, how to tell if they are sick and what to do about it. Idaho Current Information Series(146): 1 - 4.

(657) Fenwick, H. S. (1971). Diseases of perennial ornamental plants. Cooperative Extension Service, Oregon State University(Circular 780): 1 - 4.

(658) Urbano, C. C. (1986). Perennial interest in sun or shade three seasons of the year. Am Nurseryman 164(10): 41-44.

(659) Goode, H. (1973). Variety and color in the herbaceous perennial border. [Landscaping]. Garden Journal 23(4): 110 - 115.

(660) Still, S. M. (1984). Perennial propagation [Herbaceous perennials, bulbs, division and cuttings, Chrysanthemums, daylilies, Siberian iris]. Plants Gard Brooklyn Bot Gard Rec 40(1): 26-34.

(661) Powell, C. C. (1987). Disease control in the nursery : with special reference to woody and herbaceous perennials. Rev. [Columbus, Ohio?], Ohio Cooperative Extension Service, Ohio State University, [1987] 24 p. : col. ill.
This publication discusses strategies for and steps involved in disease management in the nursery with emphasis on woody and herbaceous perennial ornamentals. It includes information on plant pathogens and the diseases they cause, soil fumigation, lists of common diseases of ornamentals in Ohio, pesticide recommendations, dilution and conversion tables and Ohio Poison Information Centers.

(662) Behe, B. K. and L. Beckett (1991). Profile of the perennial plant industry. Research Report Series Alabama Agriculture Experimental Station Auburn University(7): 14-15.

(663) Dissevelt, M. and W. J. Ravensberg (1997). The present status and future outlook of the use of natural enemies and pollinators in protected crops. International Symposium on Plant Production in Closed Ecosystems. Dodrecht, Netherlands, Kluwer Academic Publishers: 49 - 65.
The use of beneficial insects and mites for the biological control of pests has increased significantly in the past thirty years. Bumblebees have been incorporated into protected crop production since the late 1980's for the pollination of vegetable crops and this stimulates greater use of natural enemies. Also the number of producers of beneficial organisms has strongly increased. The role of the market in the vending of agricultural/horticultural products is ever more important. Growers are attempting to differentiate their product and increase their market share by meeting the demands of large supermarket chains. Since 1991, quality control guidelines for natural enemies are being developed in the EU in order to standardise the quality of beneficial insect and mite products. Legislation is being prepared by an increasing number of countries for both microbiological pesticides and beneficial arthropods. The current regulations and the need for their harmonisation is discussed. How the quality control guidelines will fit into national or European legislation is not clear yet. A view of recent developments and a view of the future of biological control is given and current promoting and limiting factors are discussed.

(664) Heins, R. D., A. C. Cameron, et al. (1997). Controlled flowering of herbaceous perennial plants. International Symposium on Plant Production in Closed Ecosystems. E. Goto, K. Kurata, M. Hayashi and S. Sase. Dordrecht, Netherlands, Kluwer Academic Publishers: 15 - 31.

(665) Erdmann, G. G., T. R. Crow, et al. (1988). Foliar nutrient variation and sampling intensity for Acer rubrum trees. Can J For Res J Can Rech For 18(1): 134-139.
Mature leaves were collected during Aug. from the upper, middle and lower crown on the N. and S. sides of 22 dominant and codominant trees in even-aged stands, 51 and 58 yr old, growing on, respectively, poor and good sites in northern Michigan. Foliage was analysed for concn. of N, P, K, Ca and Mg. Although individual trees varied greatly in concentrations of all elements, trees on the good site had significantly higher concn. of P, Ca and Mg than trees on the poor site. Concn. of N, P, K and Ca also differed with crown position, but aspect did not affect foliar nutrients. The sample-size requirements are given for each element at a selected accuracy.

(666) Hill Cottingham, D. G. and C. P. Lloyd Jones (1975). Nitrogen-15 in apple nutrition investigations. Journal of the Science of Food and Agriculture 26(2): 165-173.
Young apple trees growing in pots of soil were treated with 15N-labelled KNO3 or urea at different times of year. Over periods of several months whole trees were harvested and divided into their component tissues for total N and 15N analyses; the latter were carried out using an emission spectrometer. Following treatments in mid-October 1972 and harvest in the following February, about 16% of 15N from soil-applied nitrate and almost 47% of that from leaf-applied urea was recovered in the trees. A later harvest in May 1973 showed that by then one-third to one-half of this fertilizer N had been translocated to the new leaves. Soil applications of nitrate were also made in March or August 1973 and the maximum recoveries of fertilizer N were about 40% and 60%, respectively, much of which was in the leaves. In the fruit from the March-N trees, seeds and flesh were almost equally labelled but in that from the August-treated trees the seeds contained no excess 15N, although there was a considerable concentration in the flesh. Urea foliar sprays were also made in June or August 1973. The distributions of isotope were very similar following these treatments, in that the greater part remained in the leaves.

(667) Paksasorn, A., M. Masuda, et al. (1995). Effect of fall ethephon application on bloom delay and fruit set in Japanese apricot (Prunus mume Sieb. et Zucc.). Acta Horticulturae(395): 193-200.
The Japanese apricot cultivars Shirokaga and Inazumi were given foliar applications of ethephon during the autumn of 1991 (3, 16 or 31 Oct.
or 14 Nov.) at 0, 100, 200 or 400 p.p.m., and in the autumn of 1992 (16 Oct.) at 0, 50, 75 or 100 p.p.m. The effects on flowering date and fruit
set were recorded. Ethephon application in mid Oct. delayed the date of full bloom in 1991 and 1992 by 4 and 6 days in Shirokaga and by 7 and
11 days in Inazumi, respectively. Increasing ethephon concentration markedly reduced the fruit set of both cultivars in both years. In general, the
percentage of normal flowers in Shirokaga was reduced by increasing ethephon concentration and advancing date of spraying in 1992, whereas
with Inazumi the percentage in both years was not affected by ethephon treatment. With Shirokaga, the size and weight of buds and size of flower
parts (particularly style and filament length) were reduced by 100 p.p.m. ethephon treatment on 16 Oct. 1991.

(668) Weinbaum, S. A. (1988). Foliar nutrition of fruit trees. Plant Growth and Leaf-Applied Chemicals. P. M. Neumann, CRC Press: 82 - 100.

(669) Rosecrance, R. C., R. S. Johnson, et al. (1998). The effect of timing of post-harvest foliar urea sprays on nitrogen absorption and partitioning in peach and nectarine trees. J hortic sci biotech 73(6): 856-861.
The effects of timing of autumn foliar urea-N sprays on N absorption and partitioning were studied in mature peach cv. O'Henry and nectarine cv. Fantasia trees in orchards in

California. A 10% 15N enriched urea solution was applied by either dipping individual shoots in 1995 or spraying whole tree canopies in 1996. Trees whose canopies were sprayed during the postharvest period with a 10% w:v urea solution in 1996 were excavated in the dormant season, and 15N contents and distribution were determined. Peach leaves rapidly absorbed urea-N irrespective of application date, and transport of urea-N to perennial tree parts occurred primarily within 4-7 days after application. Between 48 and 58% of the urea-N applied was recovered in abscinded leaves and perennial organs. Leaves exported _60% of the foliar-applied urea-N following application in early autumn (September or October), but <30% export occurred when the fertilizer was applied shortly before leaf fall (November). Of the urea-N translocated, most was recovered in roots (_38%) following application in September or October. Urea-N applied in November, however, remained largely in the current year wood (about 45%). Thus, export and translocation of foliar applied urea-N diminished during the final stages of leaf senescence. Foliar application of urea in September or October supplied the equivalent of about 20% of crop N content, but only 14% (about 30% lower) when applied shortly before leaf senescence in November.

(670) Coleman, W. K. and E. N. Estabrooks (1988). An evaluation of the effect of plant growth regulators on cold hardiness in apple trees. Can J Plant Sci Rev Can Phytotechnie 68(3): 859-869.
Apple growing in New Brunswick is a commercial risk; the minimum annual temperatures are very close to the -40°C isotherm, and late winter/early spring shoot damage often occurs when the shoots are non-dormant. Two-year-old trees (cv. Mac on M.106) were treated once during Sep. 1985 and again in 1986 with the plant growth regulators thidiazuron and EL-500 [flurprimidol] in the presence or absence of the antitranspirant Vapor Gard. Seasonal changes in the low temperature exotherms of twig samples, % moisture, relative dormancy intensity, % injury levels at stress temperatures of -15, -25 and -35° and daily maximum/minimum air temperatures were recorded. On a seasonal basis during the 1986-87 season, the hardiness level of the trees increased until mid-Feb. and then decreased regardless of treatment. During the acclimatization period of Sep. 1986 to mid-Feb. 1987, a significant multiple regression equation was obtained between % injury at a stress temperature of -35° and the following independent variables of % shoot moisture, previous mean maximum and mean minimum air temperatures. During the de-acclimatization period of late Feb. to May 1987, a significant regression equation was obtained betwen % injury at a stress temperature of -35° and the independent variables of % shoot moisture and previous mean maximum air temperatures. On a daily basis, fluctuating cold-hardiness levels were correlated with prior chemical treatment, prior air temperatures, % moisture levels and low temperature exotherm. The pronounced fluctuations in % injury at a stress temperature of -35° appeared to be primarily related to the previous mean maximum 3-day air temperatures when the multiple regression equations were examined for the major contributing variables. Thidiazuron in the presence or absence of Vapor Gard was effective in increasing cold hardiness on a number of occasions and appears to warrant further investigation.

(671) Himelrick, D. (1996). Gibberellic Acid to the Rescue. Fruit Grower(April): 43.

(672) Plaskeet, D. (1987). Analytical techniques for elemental analysis in plant tissues. ACIAR Proc Ser(18): 265-266.

(673) Sholto Douglas, J. (1976). Chapter 22: Solution testing. Advanced guide to hydroponics (soilless cultivation) / James Sholto Douglas. London, Pelham Books, Ltd.: 289 - 306.

(674) Neal, J. C. and A. F. Senesac (1992). Effects of herbicide residues on the establishment of oat cover crops in nursery stock. .

(675) Neal, J. C. and A. F. Senesac (1992). Effects of herbicide residues on the establishment of oat cover corps in nursery stock. Proceedings of the Northeastern Weed Science Society 46: 103.

(676) Kuhns, L., C. Haramaki, et al. (1981). Preemergence herbicides on established ornamental plants liners Abstract only. Proc-Annu-Meet-Northeast-Weed-Sci-Soc. 35: 245.

(677) Chapman, H. D. and P. F. Pratt (1982). Chapter 18: Phosphorus. Methods of analysis for soils, plants and waters, University of California: 191 - 174.

(678) Davis, T. (1997). Fertilizer testing = quality crops + maximum efficiency. Nursery Management & Production(March): 43 - 47.

(679) Frank, J. R. and C. E. Beste (1992). Clopyralid for weed control in container-grown azalea, juniper, mugo pine and taxus. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 46: 104.

(680) Senesac, A. F. and J. C. Neal (1992). Isoxaben longevity for field grown ornamentals. Proceedings of the Annual Meeting of the Northeastern Weed Science Society 46: 102.

(681) Ahrens, J. F. and M. Cubanski (1983). Herbicides for conifer seedbeds. Proceedings of the 37th annual meeting of the Northeastern Weed Science Society: 312.
Satisfactory weed control for at least 5 wk with tolerable injury to white pine, hemlock, Douglas fir and Fraser fir was obtained with 2 or 3 lb napropamide, 3 lb bifenox 4F and 0.25 lb oxyfluorfen/ac applied on newly emerged seedlings. Double these rates were tolerated except in the case of oxyfluorfen. A combination of 2 lb napropamide and 3 lb bifenox/ac in early May or napropamide followed in June by 0.25 lb oxyfluorfen/ac gave better selective weed control. Metolachlor 8E at 1.5 lb/ac and repeated after 5 wk controlled annual grasses but injured the conifers, except Douglas fir.

(682) Million, J. B., J. E. Barrett, et al. (1998). Influence of media components on efficacy of paclobutrazol in inhibiting growth of broccoli and petunia. HortScience 33(5): 852-856.
Three experiments were conducted to evaluate media component effects on paclobutrazol activity. In Expts. 1 and 2, a broccoli (Brassica oleracea var. botrytis L.) seedling bioassay was used to compare the activity of paclobutrazol at six concentrations (0-0.32 mg(.)L-1). Results from Expt. 1 indicated that an average of 4-,5-, and 10-fold higher concentrations were required in old composted pine bark, fresh pine bark, and composted pine bark samples, respectively, to achieve the same activity observed in sphagnum peatmoss (peat) samples. Activity in coir was similar to that in peat while activity in vermiculite and perlite was greater than that in peat. Activity in a fibrous peat sample was greater than in two less-fibrous peat samples. Results from Expt. 2 indicated that paclobutrazol activity was reduced more in the fine (<2 mm) fraction of fresh and composted bark samples than in medium (2-4 mm) or coarse (>4 mm) fractions. In Expt. 3, petunia (Petunia hybrida Vilm. 'Madness Red') was grown in a mixture of either 60% composted pine bark: 0% peat or 0% composted bark: 60% peat. The paclobutrazol concentration required to achieve the

same size control was 14 times higher in the former mixture than in the latter. Thus, media components differ greatly in their influence on paclobutrazol activity and the bioassay procedure may serve as a useful tool for predicting media-paclobutrazol interactions.

(683) Thorne, D. W. (1944). The use of acidifying materials on calcareous soils. J Am Soc Agron 36(10): 815-828.
1. Field, greenhouse, and laboratory experiments were conducted to determine the influence of acidifying treatments on yield and chemical composition of plants growing on various calcareous soils. 2. In a field experiment on Taylorsville silty clay loam, which contains 5 to 8% lime, the yields of wheat, potatoes, and sugar beets were not increased by sulfur, sulfur and manure compost, or phosphoric acid over the yields of comparable nonacidified treatments. In a 12-year study on Millville loam, which contains over 40% lime, sulfur and rock phosphate added to manure did not result in better yields than manure treatments alone. 2. In greenhouse studies the yields of alfalfa, barley, and corn growing on three different calcareous soils were not significantly increased by acidifying treatments, including two rates of sulfur, sulfuric acid, and phosphoric acid, over yields obtained from comparable treatments that were not acidifying. Irrigation water acidified to pH 3.0 by sulfuric acid decreased the yield of alfalfa. 3. In a greenhouse test with two calcareous soils and one noncareous soil, water acidified to pH 3.0 and to pH 5.0 with sulfuric acid had no significant effect on the yield or mineral content of tomato plants, but the treatments decreased the yield of alfalfa. Results on the noncalcareous soil were not appreciably different from those on calcareous soils. In this same experiment banded applications of sulfuric acid, dried manure, and treble superphosphate in various combinations showed no distinctive effects on calcareous soil compared with their effects the noncalcareous soil in regard to yield, or to iron, manganese, or calcium contents of tomato plants. The treatment means for all soils indicate that manure bands alone increased the concentration of iron in the plants. Sulfuric acid added to the manure further increased the content of iron but did not increase the manganese. Treble superphosphate decreased the iron and manganese contents. But the specific effects varied from soil to soil and indicate no distinctive benefits from the acid treatments on calcareous soils compared with a noncalcareous soil. 5. Alfalfa following the tomatoes was significantly decreased in yield by acidified irrigation waters. Phosphate content of alfalfa was significantly increased by the banded treatment combination of manure, sulfuric acid, and concentrated superphosphate. Other treatment effects were not significant. 6. Irrigation with waters acidified to pH 3.0, 4.0, 5.0, and 6.0 with sulfuric acid decreased the pH of three soils somewhat in proportion to the degree of acidity of the water used, but in no case was the pH of calcareous soils lowered below 7.0. 7. Water-soluble calcium determinations gave more consistent values in relation to the effects of sulfur and sulfuric acid treatments than did pH. Phosphoric acid decreased the pH of some soils but did not increase the calcium solubility. Farm manure treatments did not result in changes in either pH or soluble calcium in soils. The acidifying treatments showed no relationship to phosphorus soluble in a pH 5 acetate buffered solution. 8. A consideration of the results of this study and other reported investigations on the use of acidifying materials on calcareous soils indicates that there is insufficient evidence to date to warrant any widespread recommendation of such treatments for benefiting plant nutrition and growth. The value of acidifying agents in preventing phosphate reversion in calcareous soils has not been studied extensively enough to warrant conclusions.

(684) Messenger, A. S. and J. L. Nesbit (1998). Effects of soil acidification on growth and nutrition of white oak seedlings. Communications in Soil Science and Plant Analysis 29(7/8): 793-807.
Nine surface soil acidification treatments were tested to determine which were effective in preventing the development of chlorosis in white oak seedlings. The treatments were applied with and without subsurface sulfuric acid to white oak seedlings purposely planted in calcareous soil. Nutrient imbalances as compared to healthy seedlings consisted of low foliar nitrogen, phosphorus, zinc, iron, and copper for uniformly chlorotic seedlings. Interveinally chlorotic seedlings exhibited low nitrogen and iron and high potassium. Miracid, Hi-Acid, and ammonium sulfate surface treatments were highly effective in preventing chlorosis provided that subsurface treatment was omitted. Except when applied with H2SO4, Al2SO4, and granular sulfur surface treatments, subsurface H2SO4 had an adverse effect on treatment success.

(685) Berglund, K. (1996). Agricultural improvement of cultivated organic soils. I. Effects of deep cultivation, liming, irrigation and P-fertilization on crop yields. Soil use manage 12(4): 169-175.
Four field experiments were carried out on cultivated shallow fen peat overlying acid gyttja (lake mud) soil. The accessibility of the generally ample supply of physically available water was restricted by a limited root depth caused by low pH and high levels of aluminium in the subsoil. In order to improve the nutrient status and the crop water supply of the soils liming, deep cultivation, P-fertilization and irrigation were tested in field experiments comprising these four main treatments and their combinations. Liming and P-fertilization of the topsoil, irrigation and deep cultivation in combination with deep liming improved crop yields. Deep cultivation without liming had a negative effect on yield in most years.

(686) Berglund, K. (1996). Agricultural improvement of cultivated organic soils. II. Effects of liming and deep cultivation on soil properties and root development. Soil use manage 12(4): 176-180.
The effect of liming and deep cultivation on soil properties and root development was investigated in two cultivated shallow fen peats resting on acid gyttja (lake mud) soils. Root growth was in general dependent on soil pH and aluminium content of the soil. A soil pH (H2O) below 5 adversely affected roots and a pH below 4 severely restricted root growth. Liming of the topsoil or the subsoil and to some extent deep cultivation improved root growth. Increased rooting depth made it possible for plants to utilize soil water to a greater depth in the profile and to support a larger crop yield.

(687) Suarez, E. L. and U. S. Jones (1982). Atmospheric sulfur as related to acid precipitation and soil fertility. J Soil Sci Soc Am 46(5): 976-980.
In experiments conducted to determine the major acidic components of precipitation in the southeastern United States, amounts of sulfur (S) deposited on the soil with rainfall were estimated and relationships between applied sulfur and crop yields in South Carolina were established. The average loading concentration of anions in rainwater increased during the spring-summer months and decreased during the fall-winter months. Sulfuric and nitric acids were found to be the major components of acid rainfall. Rainfall and air deposition contributed approximately 10.7 and 1.8 kg/ha of sulfur per year, respectively, at Clemson. Atmospheric deposition from the particulate matter contributed an estimated 3.0 kg/ha of sulfur during the year. Increases in corn grain and silage yields were obtained with the application of 18 kg/ha of sulfur at Darlington, S.C. A relationship between applied sulfur and crop response for the other crops considered could not be established. A need for reevaluating the findings and recommendations for sulfur fertilizers was apparent

because of the contribution of atmospheric-deposited sulfur to the soil and plant sulfur supply.

(688) Cowling, W. A. and J. C. Clements (1993). Association between collection site soil pH and chlorosis in Lupinus angustifolius induced by a fine-textured, alkaline soil. Aust j agric res 44(8): 1821-1836.

Collection site soil pH may be a useful predictor of tolerance in Lupinus angustifolius to chlorosis induced by alkaline soils. We examined a range of genotypes from the Mediterranean region for their tolerance of an alkaline sandy clay loam (pH 8.8) from Merredin, Western Australia. Fifteen wild L. angustifolius lines, collected on a variety of soils that ranged in pH from 4.2 to 9.0, were compared with cultivars of L. angustifolius and known alkaline-tolerant (L. cosentinii) and alkaline-sensitive (L. luteus) lupin species. Five-week-old seedlings varied greatly in chlorosis on the alkaline soil, from almost no chlorosis (as in L. cosentinii cv Erregulla) to severely chlorotic (L. angustifolius line MJS176 from Spain). No lines were chlorotic after acid amelioration of the soil. Chlorosis score in wild L. angustifolius was not significantly correlated with soil pH at the collection site and was not associated with a particular soil texture, but there was a significant correlation between altitude of collection sites and chlorosis scores. Chlorosis-sensitive lines were from higher altitudes, had lower root and shoot fresh weight, were lower in Fe, Mn and K and were higher in Zn, P, and S in new growth than resistant lines. Chlorosis-sensitive lines also had the largest increases in fresh weight of roots and shoots in response to soil acidification. Genotypes with better root growth and therefore lower chlorosis symptoms on alkaline soil did not necessarily have the strongest root growth on acid ameliorated soil. Soil pH at the collection site in the Mediterranean region was not a reliable predictor of chlorosis in L. angustifolius induced by an alkaline was found within the species.

(689) Hodge, T. J. V. and D. C. Lewis (1989). A description of acid soils and the relationships between properties of acid soils and the nutrient status of grazed pastures in the south-east of South Australia. Australian Journal of Soil Research 27(1): 149-159.

Areas of low soil pH in South Australia were delineated from previously submitted soil samples and soil association maps. A survey was then undertaken in the major soil associations to determine the severity and characteristics of highly acid soils. The acid soil types identified were a siliceous sand over clay and a siliceous sand over organic matter/sesquioxide pan. The top 2.5 cm of both soil types was significantly less acid than the remaining portion of the A horizon, with pH decreasing rapidly with depth until the B horizon, where a substantial soil pH increase occurred. As soil pH (0.01 M CaCl2) decreased below 4.5, extractable soil aluminium (0.01 M CaCl2) increased rapidly, to a maximum extractable concentration of 17 mug/g. These soils were also deficient in both phosphorus and potassium, with 65% of the sites having extractable phosphorus concentrations below the critical value of 20 mug/g and 35% below the critical value for extractable potassium of 80 mug/g. For subterranean clover, significant positive correlations were observed between soil pH and plant calcium and sulfur, and between extractable soil aluminium and plant aluminium. Significant negative correlations were observed between soil pH and plant manganese and between extractable soil aluminium and plant calcium and magnesium. For ryegrass, significant positive correlations were observed between extractable soil aluminium and plant aluminium and manganese. Significant negative correlations were observed between soil pH and plant manganese and between extractable soil aluminium and plant calcium. No other significant correlations were obtained. These results are discussed in relation to further acidification and management of these acid siliceous sands.

(690) Timmer, V. R. (1985). Response of a hybrid poplar clone to soil acidification and liming. Can J Soil Sci Revue Can Sci Sol 65(4): 727-735.

Unrooted hybrid poplar cuttings were grown in a greenhouse at varying soil pH. The soil was a loamy fine sand (pH 5.7) collected from an

Ap horizon of a forest tree nursery. The pH was adjusted over a wide range by incorporating different rates of powdered lime or elemental sulfur.

Lime additions failed to improve growth significantly over a 20-wk period, and excessive liming to pH 7.6 reduced shoot dry weight by 33%,

probably because of decreased availability of micronutrients. Sulfur, acidifying the soil to pH 4.1, depressed growth as much as 76%. This growth

inhibition was closely associated with increased Al in both foliage and soil as well as reduced foliar uptake of the other essential nutrients.

Maximum height growth of clone DTAC-32 occurred between pH 6.0 and 7.0, which falls within the general guidelines for producing hardwood

nursery stock.

DE:

(691) Bole, J. B. (1986). Amelioration of a calcareous Solonetzic soil by irrigation, deep ripping, and acidification with elemental sulfur. Can J Soil Sci Revue Can Sci Sol 66(2): 347-356.

The effect of leaching, deep ripping, and acidification by bacterial oxidation of elemental sulfur on the amelioration of a calcareous Solonetzic soil over four seasons was investigated by measuring changes in soil chemical properties, infiltration, and crop yields. Weekly applications of 12-25 mm of irrigation water for 9 wk in 1981 and 11 wk in 1982 leached over half of the soluble salts from the surface 60 cm of a Solonetzic soil. Sodium was more readily leached than Ca + Mg so that the SAR was reduced from more than 20 to less than 10 throughout the surface 60 cm. Further amelioration resulted from normal irrigation practices consisting of three 4-h applications of 50-60 mm of water in 1983 and 1984. Ripping with a subsoiler to a depth of 50-60 cm did not significantly affect the reclamation but the surface infiltration rate and hydraulic conductivity remained higher 3.5 yr after tillage compared with the control. Oxidation of elemental S (3.3 t ha-1) applied in 1981 resulted in a decrease in pH of the surface 15 cm of soil from 7.2 to 5.3 after two irrigation seasons. Naturally occurring lime was dissolved by the S treatment, increasing the soluble Ca + Mg and total salts and decreasing the SAR. These effects were no longer evident after the 1984 irrigation season. Yields of spring barley (Hordeum vulgare L. 'Johnston') were not affected by the tillage or S treatments.

(692) Owen, K. M., R. H. Marrs, et al. (1999). Soil acidification-the use of sulphur and acidic plant materials to acidify arable soils for the recreation of heathland and acidic grassland at Minsmere, UK. Biological Conservation 87(1): 105-121.

Experiments were conducted at Minsmere, UK to acidify the arable soils (pH 6-7) to heathland levels (pH 3.5-4) by the addition of varying amounts of elemental sulphur (S), bracken litter and pine chippings. All rates of S addition reduced soil pH, although the efficacy of acidification was related to the application rate. Rates of 1 and 2 t S/ha produced soils of c. pH 4. Rates of 8 t S/ha and above reduced the soil pH to < pH 3. Equations were derived for two fields to enable calculations of the S additions required to reduce pH to a given value. Bracken litter reduced soil pH to 4-4.5, and pine chippings reduced the soil pH by 0.5-1 unit to pH 5.5. The addition of pine chippings was not an effective means of acidifying the soil where large reductions in pH are needed. Soil acidification did not significantly increase the available

concentrations of Ca, Mg, K and P, indeed reductions in extractable P and exchangeable Ca were found, which may aid the establishment of heathland and acid grassland species. The reduction in soil pH brought about by the addition of bracken litter was not sufficient to inhibit the growth of arable weeds that compete with heathland vegetation. S was the most effective means of acidifying the soil, but at high application rates caused acidification through the soil profile, which could be problematic should leaching occur into water courses. A combination of low rates of S application coupled with the addition of bracken litter may offer the best solution, although further experiments are needed to test this approach.

(693) Beverly, R. B. (1987). Celery response to foliar nutritional sprays and acidification of a histosol. HortScience 22(6): 1271-1273.
Response of the cv. Florida 683 to soil acidification and foliar Mn application was evaluated in a field experiment on a Histosol of near-neutral pH. Acid sources (powder 90% S, granular 92% S, granular 80% S + 5% Mn and acidified iron sulphate slag 20% Fe + 25% S) varied in their effectiveness in reducing pH when broadcast at 1120 or 2240 kg/ha or band-applied at about 200 kg/ha. Broadcast application increased yield, compared with the control or band treatments, but band application of a granular S and Mn product proved superior to the other band treatments. Soil and foliar treatment (with Micro-Fol 1990 containing N, K, Mn, S, Fe, Cu, Zn and B, or Tecmangam containing 27% Mn) interaction data showed that the strategies were substitutionary. Foliar Mn application was found more economical than soil acidification, but soil acidification, especially by band application of a low rate of S and Mn together, was cost-effective.

(694) Barak, P., B. O. Jobe, et al. (1997). Effects of long-term soil acidification due to nitrogen fertilizer inputs in Wisconsin. Plant and Soil 197(1): 61 - 69.
In a long-term soil fertility trial in south-central Wisconsin, USA, significant increases in exchangeable acidity were accompanied by decreases in cation exchange capacity (CEC), base saturation, and exchangeable Ca2+ and Mg2+ with application of ammoniacal N fertilizer. Analysis of the aboveground biomass of a 1991 sweetcorn crop showed that a considerable portion of the alkalinity generated by assimilation of N (and to a lesser extent by S) is sequestered in the aboveground plant parts as organic anions and is not returned to the soil if harvested. Elemental analysis of Ca-saturated soil clays indicates a loss of 16% of the CEC of the soil clay and minor increases in Fe and Al. The reversibility of these changes due to prolonged acidification is doubtful if the changes are due to soil weathering.

(695) Cline, G. R. and K. Kaul (1990). Inhibitory effects of acidified soil on the soybean/Bradyrhizobium symbiosis. Plant and Soil 127(2): 243-249.
Effects of acidic soil factors (Al, H-ion, Mo, and Mn) upon the soyabean cv. Essex/Bradyrhizobium japonicum symbiosis were examined in acidified soil. Plants were grown under full sunlight in pots containing N-deficient soil (pH 6.7) or similar soil amended with sufficient Al2(SO4)3 or elemental S to give soil pH values of 4.8 and 4.6, resp., and water-extractable Al levels of 30 and 14 μM, respectively. Other treatments consisted of the addition of inorganic N or inoculation with commercial or locally-isolated B. japonicum. Acidification did not reduce shoot or root FW of plants receiving inorganic N but reduced shoot and root DW, nodule DW and numbers, shoot N concn, and chlorophyll levels of inoculated plants. Shoot DW and nodulation of inoculated plants were greater in Al2(SO4)3-amended soil than in S-amended soil. Addition of Mo was not beneficial. It was concluded that reduced plant growth was caused by the effects of acidified soil on nodulation and that H-ion toxicity was probably the most limiting factor rather than Al or Mn toxicity, Mo deficiency or high salt levels.

(696) Fraps, G. S. and J. F. Fudge (1936). The effect of sulfur and sulfuric acid upon the development of soil acidity at different depths. J Am Soc Agron 28(12): 1012-1016.
Different quantities of sulfuric acid and sulfur were added to the surface 5 inches of a Lufkin fine sandy loam in 18-inch tiles, and the pH values of samples of the soils from different depths were determined at intervals over a 5-year period. Maximum acidity of the surface soil developed within 10 weeks and that of the next 2 or 3 inches within 4 months after treatment. Acidity of all treated soils then slowly decreased. Penetration of acidity in excess of 2 or 3 inches occurred only in series in which the surface soil became so acid that no plant growth could occur. The presence of free sulfuric acid and soluble salts in the soil solution was evident from the pH values secured. Increases in exchangeable hydrogen at the end of 5 years were equivalent to an average of about 60% of the acid added. The remainder of the acid must have reacted with non-exchange compounds in the soil, including bases made available by weathering. Single applications of acid to the surface soil is not a practical method for acidifying the subsoil for the control of plant diseases.

(697) Chapman, H. D. (1936). Effect of nitrogenous fertilizers, organic matter, sulfur, and colloidal silica on the availability of phosphorus in calcareous soils. J Am Soc Agron 28(2): 135-145.
Pot culture studies with Sudan grass to determine the effect of various nitrogenous fertilizers, sulfur, colloidal silica, and organic matter on the availability of phosphorus in three calcareous soils have shown the following: 1. Physiologically acid nitrogen fertilizers increased phosphate availability, the magnitude of the effect being related to the carbonate-phosphate ratio of the soil and the nature of the materials used. 2. Sulfur markedly increased phosphate availability in all of the soils studied, being particularly effective on a soil low in carbonate and high in phosphate. 3. Colloidal silica slightly increased phosphate availability. 4. Sodium silicate was without effect. 5. Filter paper added without phosphate applications depressed the yields of Sudan grass presumably as a result of the competition for phosphate between cellulose-decomposing organisms and the plants. When filter paper was supplemented by phosphate, the yields were greater than those obtained with phosphate alone, indicating that carbon dioxide or other decomposition products of the filter paper increased phosphate availability. On the other hand, no effects were obtained from ground barley straw other than those which might be ascribed to the phosphorus it supplied.

(698) Ali, A. M. S. and J. L. Stroehlein (1991). Reactions of urea phosphate in calcareous and alkaline soils. II. Effects on soil sodium and salinity. Communications in Soil Science and Plant Analysis 22(11/12): 1257-1268.
A study was made to determine the effectiveness of urea phosphate (UP) in reducing soil alkalinity and NH3 loss when ammonium forming fertilizers are applied to alkaline soils. The volatilization of NH3 from UP and urea (U) was studied on 3 selected soils (Hayhook SL, Laveen L and Latene L) using an aeration system. Urea phosphate and U were each applied at rates of 0, 50, 100 and 200 ppm-N either to the surface dry or in solution or mixed with the soil. The volatilized NH3 was trapped in sulfuric acid, sampled periodically and analyzed for N using the semi microkjeldahl distillation apparatus. The effect of UP, sulfur-foam (SF), phosphoric solution (PHP, a mixture of urea, phosphoric acid and sulfuric acid) and a mixture of SF and UP on leaching soil sodium and salinity was also studied in two soils (Pima L and Crot CL) in columns. Each of these amendments was applied at a

rate of one and two equivalent amounts of the exchangeable sodium C Naex. The highest N loss in the form of NH3 occurred when urea was applied to Hayhook soil. However, UP applied to Hayhook soil (neutral to acidic, coarse textured and low CaCO3 content) resulted in the lowest NH3-N loss. Less NH3-N loss was found from U application to Laveen and Latene soils (fine textured with higher CaCO3 content) than with Hayhook soil. The general trend was higher N loss, in the form of volatilized NH3, with surface application dry or in solution than when mixed with the soil. This trend showed an increase in the amount of volatilized NH3 with increasing rate of N application. Urea phosphate was as effective as PHP or a UP-SF mixture (acid containing fertilizers) treatments in reducing soil salinity and alkalinity in Pima and Crot soils. No difference was found between rates of application (1 and 2 equivalent amounts of Naex) except for soil pH. A similar trend in the decrease in soil salinity was found to that of the pH which was in the order PHP, UP, UP-SF mix, SF and control treatments. No significant difference was found between SF and control treatments in all parameters. No significant difference was found between treatments for exchangeable Ca. This was affected by the Ca compounds present in the soil. UP is a potential fertilizer for supplying N and phosphorus (P) as plant nutrients, reducing NH3 volatilization, and can be used as a soil amendment to control soil salinity and alkalinity.

(699) Zhao, F. J., S. Y. Loke, et al. (1996). Method to determine elemental sulphur in soils applied to measure sulphur oxidation. Soil Biol Biochem 28(8): 1083-1087.
A method was established for the determination of elemental S (S degrees) in soils. The S added to four arable soils was extracted with chloroform, digested with fuming HNO3-KNO3 and determined using inductively coupled plasma atomic emission spectroscopy (ICP-AES). The method gave recoveries of between 96.6 and 100.4% in air-dried soils and in the same soils at 50% of the water holding capacity (WHC), with CVs varying between 0.4 and 5.6%. Complete recoveries were also obtained at soil moisture contents of 2 and 4 times of WHC, although precision was poorer. In contrast, the digestion method using HClO4<HNO3 was not suitable, because it resulted in only about 80% recovery of S degrees. An incubation study showed that the net amount of sulphate-S produced was substantially less than the decrease of S degrees in four soils. After 38 days of incubation at 25 degrees C, the percentages of total oxidised S appearing as sulphate-S were greater in the two sandy soils (64-78%) than in the two clayey soils (34-40%). The difference between the oxidation of S degrees and the production of sulphate-S was probably due to microbial immobilisation. It is suggested that both measurements are needed to study the oxidation of S degrees in soils and the availability of oxidised S to crops.

(700) Beverly, R. B. and D. L. Anderson (1987). Effects of acid source on soil pH. Soil Sci 143(4): 301-303.
Ten acid sources, including granular and powdered forms of elemental S, iron sulfate slag, ferrous sulfate, and ammonium sulfate were added in equivalent amounts to two Histosols and three Alfisols typical of soils from the Everglades, and the soils were incbated for over 6 mo. At 2240 kg S ha-1, the powdered form of S was more effective in lowering soil pH than the granular sources of S. Little difference was found between the granular S products. Ferrous sulfate and ammonium sulfate lowered soil pH more than the elemental S products.

(701) Sverdrup, H., P. Warfvinge, et al. (1994). Assessment of soil acidification effects on forest growth in Sweden. Water, Air, and Soil Pollution 78(1/2): 1-36.
The results of mapping critical loads, areas where they have been exceeded and steady state (Ca+Mg+K)/Al ratios of soils in Sweden, has been used to assess the order of magnitude of the ecological and economic risks involved with acid deposition for Swedish forests. The results of the calculations indicate that 81% of the Swedish forested area receive acid deposition in excess of the critical load at present. Under continued deposition at 1990 level, forest die-back is predicted to occur on approximately 1% of the forested area, and significant growth rate reductions are predicted for 80% of the Swedish forested area. For Sweden, growth losses in the order of 17.5 million m-3 yr-1 is predicted, equivalent to approximately 19% of current growth. Comparable losses can be predicted for other Nordic countries. The soil acidification situation is predicted to deteriorate significantly during the next 5-15 years, unless rapid emission reductions can be achieved. A minimum deposition reduction over Sweden of 85% on sulphur deposition and 30% on the N deposition in relation to 1990 level is required in order to protect 95% of the Swedish forest ecosystems from adverse effects of acidification. A minimum reduction of 60% on sulphur deposition and 30% on the N deposition is required to keep forest harvest at planned levels.

(702) Lore, J. A. (1984). Observations of pH in field soils near a sour gas plant in Alberta [Effects of sulfur dioxide emissions on soil acidification]. Water, Air, and Soil Pollution 21(1/4): 403-410.
Soil pH was observed in natural soil profiles over 9 yr near a sour gas plant in southern Alberta. Samples were collected during the spring and fall from 1973 to 1981 at 10 replicated sites. No acidification trend in pH was observed.

(703) Cline, G. R. and A. F. Silvernail (1997). Effects of soil acidity on the growth of sericea lespedeza. Journal of Plant Nutrition 20(12): 1657-1666.
Field experiments were conducted in 1992 and 1993 to examine effects of soil acidity on growth and N2 fixation by "Serala" sericea lespedeza [Lespedeza juncea (L.F.) var.sericea (Mig.)]. Effects of acidified soil on N2 fixation could not be determined because nodulation was suppressed, apparently by sufficient availability of N. Apparently-suppressive, mean 1993 levels of KCl-extractable NH4 and NO3 in zero nitrogen (N) control treatments were 20 and 13 mg.kg-1, respectively. In soil acidified with sulfur (S), growth of sericiea lespedeza was significantly reduced (P<0.05) when the concentration of water-extractable Mn exceeded 1.3 mM or calculated Mn2+ activity exceeded 0.4 mM. This occurred at pH values of 4.1 to 4.3 depending on S treatment. At a given value of pH, shoot dry weight production was greater in S-amended soil than in Al2SO4-amended soil. Reduced growth in the latter did not appear to be directly related to higher measured levels of toxic Al but may have been caused by a combination of aluminum (Al), hydrogen (H), manganese (Mn), and phosphorus (P)effects. Lespedeza growth was lowest in nonacidified soil with pH values near 6.0, indicating a preference for acid soils by the variety "Serala." The demonstration tolerance of sericea lespedeza to acid soils make it a valuable reclamation species. However, Mn may inhibit growth in acidic soils when the activity of water-extractable Mn2+ exceeds 0.4 mM, and it may not fix appreciable N2 unless available soil N is quite low.

(704) Janzen, H. H. and J. R. Bettany (1987). Oxidation of elemental sulfur under field conditions in central Saskatchewan. Canadian Journal of Soil Science 67(3): 609-618.
A field study was conducted at 4 sites in central Saskatchewan to examine the oxidation rate of elemental S and its influence on soil pH. Finely divided S (approximately 7-mum diameter) was applied at a rate of 200 kg ha-1 to soil cores in aluminum cylinders. Three entire cores from each site were removed and analyzed for sulfate content and soil pH four times during a 16-mo period. All four soils exhibited significant oxidative activity. 23-45% of applied S was recovered as sulfate 10 wk after application. Sulfate

concentrations recovered in the soil profiles declined after approximately 1 yr, partly owing to leaching losses. Fertilizer-derived sulfate was most persistent in soils of finer texture. In the coarse-textured soils, most of the fertilizer-derived sulfate was apparently leached from the soil profile by the end of the 16-mo period. Soil pH was marginally reduced by oxidation following the application of elemental S, but differences were no longer statistically significant at the last sampling time. Field incubation with elemental S substantially enchanced subsequent oxidative activity in three soils, suggesting that an initial application of elemental S fertilizer would enhance the effectiveness of subsequent applications. Substantial oxidation activity occurs in Saskatchewan soils even under the less than ideal conditions prevalent in this climatic region. It was concluded that elemental S in a finely divided form has strong potential as an effective fertilizer S source if appropriate fertilization strategies are adopted to maximize oxidation rate or compensate for delays in plant-available S release.

(705) Neilsen, D., E. J. Hogue, et al. (1993). Oxidation of elemental sulphur and acidulation of calcareous orchard soils in southern British Columbia. Canadian Journal of Soil Science 73(1): 103-114.
The capacity of soils to oxidize S was measured by incubation with finely divided elemental S in 13 calcareous orchard soils from the southern interior of British Columbia. Sulphur oxidation rates ranged from 3.4 to 26 mu-g S cm-2 d-1. The magnitude of pH decrease in response to added S varied inversely with initial CaCO-3 content (r = -0.58, P = 0.04) and silt content (r = -0.64, P = 0.02) and directly with sand content (r = 0.64, P = 0.02). Incubation studies with one calcareous orchard soil indicated that finely divided S was more effective over time than other acidulants (FeSO-4, Al-2 (SO-4)-3 and H-2SO-4). A field study was carried out on the same soil. Finely divided and bentonitic granulated S were applied at 4.5 t ha-1 on the grass surface or incorporated to a depth of 15 cm. Incorporated fine S was oxidized to a much greater extent during a 2-yr period than was incorporated grandulated S. However, when surface applied, they were oxidized equally but slowly.

(706) Zandstra, B. H., W. R. Chase, et al. Interplanted small grain cover crops in pickling cucumbers. HortTechnology 8(3): 356-360.
In trials in Michigan in 1991-95, pickling cucumbers for machine harvest were interplanted with barley, oats, rye, sorghum-sudan (Sorghum vulgare [S. bicolor]) or wheat. Cover crops sown at _129 seeds/m2 provided protection from wind erosion and minimal crop competition. Additional nitrogen to obtain maximum yield was required when small grain cover crops were interplanted with cucumbers. Cover crops were killed with sethoxydim. Barley emerged rapidly, grew upright and was killed easily with sethoxydim, making it ideal for interplanting. All cover crops caused some cucumber yield reduction under adverse growing conditions.

(707) Hochmuth (1992). Tips on plant sap testing. American Vegetable Grower(August): 23 - 25.

(708) Minotti, P. L., T. J. Hankinson, et al. Whole leaves versus petioles for assessing the nitrogen status of tomatoes. HortScience 24(1): 84-86.
Plants were sampled for laboratory analysis of NO3-N in one greenhouse- and 4 field experiments. A ratio of about 3:1 for petiole NO3-N to whole leaf NO3-N was found over a wide range of conditions for the third leaf below the growing tip and leaves below this point. The ratio was higher for very young leaves. Nitrate-N increased with leaf age and then remained relatively constant. Whole leaves were as effective as petioles for reflecting changes in available N.

(709) Kabashima, J., T. D. Paine, et al. Successful strategies for reducing pesticide use in the landscape: examples from California. HortTechnology 8(2): 150-153.
Pesticide use in the landscape has been reduced through the implementation of integrated pest management (IPM). IPM emphasizes prevention, identifying pests and their symptoms, regular surveying for pests, determining action thresholds and guidelines, and using sound management methods. Monitoring techniques such as pheromone traps, degree-day models, and ELISA kits, in addition to traditional methods, have enabled pest managers to determine accurately when to apply IPM techniques. Examples of serious California landscape insect pests successfully controlled through IPM include the ash whitefly (Siphoninus phillyreae), the Nantucket pine tip moth (Rhyacionia frustrana) and the eucalyptus longhorned borer (Phoracantha semipunctata).

(710) Hallett, R. A. and J. W. Hornbeck Foliar and soil nutrient relationships in red oak and white pine forests. Can j for res 27(8): 1233-1244.
Red oak (Quercus rubra L.) and white pine (Pinus strobus L.) forests on sandy soils of the northeastern United States may have been depleted of nutrient cations by acid precipitation and intensive land use. Foliar Ca in oak was 5260 mg Ca.kg-1 dry matter, or more than 3 times the amount in white pine foliage. Red oak also has more Mg, K, and N than white pine. Foliar Al concentration for white pine foliage, 132 mg Al.kg-1 dry matter, was twice that of red oak foliage. Foliar Ca and N was correlated with basal-area increment. Foliar Ca/Al ratios and Mg levels in pine folia suggest a risk to tree health. In the organic horizons of both oak and pine forests, bases occupied 80% of the exchange sites. However, in the mineral horizons, Al occupied 96% of the exchange sites. Al may be accumulating in the O horizon. These data indicate that both forest types are susceptible to nutrient imbalances and deficiencies that result from atmospheric deposition and harvesting.

(711) Kidder, G., M. J. Holsinger, et al. Lowering of calcareous soil pH in Field-Grow containers. Journal of Environmental Horticulture 8(1): 1-4.
Wettable sulphur mixed with a Pineda fine sand (an Arenic Glossaqualf of pH 7.8 and 1.5% CaCO3 equivalent) quickly acidified the soil, but the effect was lost within 8 weeks at low application rates and within 21 weeks at the highest rate (1 g S/kg soil). Granular S mixed with the soil took one year to produce maximum pH reduction of 0.3, 0.4 and 0.9 pH units at 250, 500 and 1000 mg S/kg soil, respectively. Wettable sulphur (S), at 100 g/m2, reduced the pH of the upper 5 cm of soil to 5.6-5.8 for 1-2 months before the pH returned to >7.0; granular S took about 5 months to reduce the pH to 6.7 but the pH increased to 6.2 after 2 years from application. Wettable S at 29 g/kg soil applied in a small cylindrical zone resulted in a temporary depression of pH within the treated zone but had no effect on pH in other areas of the container. Mixing up to 1.0 g FeSO4/kg soil failed to reduce soil pH. Stem diameter and plant height of Quercus virginiana plants were not affected by any of the soil treatments.

(712) Nyborg, M. and S. S. Malhi (1991). Acidification of forest soil by elemental sulphur dust. Dev Plant Soil Sci 45: 555-563.
Elemental sulphur (S(o)) dust blew from a sour gas processing plant into coniferous forest in northwestern Alberta. The objectives were to determine the amounts of wind-blown S(o) deposited on the soil, its effect on soil pH and vegetation, and to find methods of reclamation of the S(o)-acidified soils. Wind-blown S(o) apparently did not travel beyond 3 km downwind from the S(o) source. S(o) deposition within 200 m of the source had made the

soil extremely acid and most of the vegetation was dead. Two acidified soils (pH 1 to 2) were used in greenhouse experiments with treatments including heavy dose of finely-ground CaCO3 (353 t ha-1). Oats and reed canary grass grew well on CaCO3 treated soil, but only with NPK fertilizer. Field experiments gave similar results. A large area (within 650 m) was Luvisolic soil with the litter layer acidified to <pH 3 and most of shrubs and all of mosses were gone. Here the mineral N did not accumulate whether the soil was limed or not and N fertilizer disappeared from the mineral N pool soon after application, indicating immobilization of mineral N by S(o) oxidation. Natural re-vegetation was extremely slow despite liming, but agricultural species grew provided they received repeated additions of N fertilizer. Farther from the S(o) source (up to 2.5 km) the moss stratum was dead or dying when the pH of the 0-2.5 cm soil layer was less than 3.6 to 3.9 and buffering capacity of that layer against dilute H2SO4 was especially low. However, mosses were not harmed by application of finely-ground lime.

(713) **Lockhart, J. M. and C. A. Sanchez (1990). Acidification of an Everglades histosol using several fertilizer sources. Proc Annu Meet Fla State Hortic Soc 102: 344-345.**
A Histosol with an initial pH of 7.0 was acidified using 5 compounds (ammonium nitrate, ammonium sulphate, urea/ammonium nitrate solution, phosphoric acid or elemental S) which are often applied as fertilizer in the Everglades Agricultural Area. The N sources and the phosphoric acid treatment achieved their full potential in decreasing soil pH 21 d after treatment. Elemental S was the least effective treatment both in terms of rate and magnitude of soil acidification. Higher soil pH values for the ammonium sulphate and urea/ammonium nitrate solution treatments left on the soil surface for 4 d prior to discing indicated that losses of NH4-N may have occurred before incorporation. Other than a slight stand reduction with ammonium nitrate, the acid sources did not deleteriously affect the growth of radishes planted 6 d after treatment. However, there was a significant decrease in the incidence of root cracking with a decrease in soil pH.

(714) **Hegazi Hassan, A., A. F. Abdelal, et al. (1974). Effect of foliar-applied urea on the nitrogen content in apple leaves. Jugoslovensko Vocarstvo 8(28): 19-23.**
Urea sprays at 15 lb/100 gal severely injured the leaves of the cv. Red-Volse, whereas rates of 3 to 10 lb/100 gal caused no visible injury. The sprays increased temporarily the leaf N content, but 2 weeks after spraying the N level decreased to nearly that in the unsprayed control. Spraying in June or July resulted in similar N absorption.

(715) **Janzen, H. H. (1990). Elemental sulfur oxidation as influenced by plant growth and degree of dispersion within soil. Canadian Journal of Soil Science 70(3): 499-502.**
Controlled environment studies were conducted to characterize the effects of cropping treatment and degree of particle dispersion on S oxidation rate. In two soils (a Chernozem and a Luvisol), S oxidation rates were not greatly affected by cropping treatment (barley, beans, canola, or fallow). In a second experiment, S oxidation was shown to approach maximum rates at a dispersion level of 1000 g soil/g S.

(716) **Putnam, A. R. and J. F. Hancock (1982). Influence of napropamide on strawberry growth and fruit yield Herbicides. Hortsci 17(4): 650-651.**
Preplant-incorporated and post-transplant applications of napropamide were compared with 2 standard preemergence herbicides (diphenamid and chlorthal-dimethyl) for safety on newly transplanted Midway strawberries. Napropamide at rates up to 4.4 kg/ha caused no reduction in runner or daughter plant production, or in the rooting of daughter plants. There was no adverse effect on fruit yield the following season compared with hand-weeded controls. Slightly higher yields were obtained when herbicides were preplant-incorporated.

(717) **Nodvin, S. C., C. T. Driscoll, et al. (1986). The effect of pH on sulfate adsorption by a forest soil. Soil Sci 142(2): 69-75.**
Acidic deposition and forest clear-cutting are disturbances that have resulted in increased acidification of northeastern forest ecosystems. This study was conducted to evaluate whether acidification processes can significantly affect adsorption processes that are important in regulating sulfate transport and cycling in a Spodosol at the Hubbard Brook Experimental Forest, New Hampshire. The results of adsorption experiments demonstrated that small changes in solution pH have a large effect on sulfate adsorption characteristics of mineral soil at Hubbard Brook. The ability of the soil to remove sulfate from solution increased as the pH of the solution was decreased, with a maximum removal occurring at about pH 4.0. The use of initial mass isotherms showed that sulfate removal depended upon (1) the ability of the soil to partition sulfate between the soil and solution phases and (2) the amount of reactive native sulfate that is present in the soil. It is demonstrated that both these soil properties depend strongly upon solution pH.

(718) **Warren, C. J. and M. J. Dudas (1992). Acidification adjacent to an elemental sulfur stockpile. I. Mineral weathering. Canadian Journal of Soil Science 72(2): 113-126.**
The influence of extreme acidity on the changes and redistribution of major chemical and mineralogical components in soil along the side of a 25-year-old elemental sulfur stockpile was studied. Soil samples, obtained from pits located 2 m from the side of the stockpile, were analysed for total content of Al, Fe, Ca, Mg, Na, K, and Ti. Sand and clay separates were analysed by X-ray diffraction, and physical and chemical methods to identify and quantify mineral phases. Carbonate, Fe-containing primary minerals, chlorite, smectite, and plagioclase felspars were either partially or completely dissolved in soil with pH values of _ 2.1. Clay-sized mica and kaolinite were apparently not affected by the acidity. Calcium carbonate and Ca-felspars dissolved in the presence of H2SO4 to form gypsum. Iron dissolved from minerals in the acidified surface layer was deposited primarily as oxyhydroxides at the interface of acidic and calcareous materials to form an indurated layer about 10-15 cm thick. Jarosite precipitated within the acidic material just above the indurated layer.

(719) **Warren, C. J. and M. J. Dudas (1992). Acidification adjacent to an elemental sulfur stockpile. II. Trace element redistribution. Canadian Journal of Soil Science 72(2): 127-134.**
Total concn of Ag, As, B, Ba, Co, Cr, Cs, Ga, Hf, Hg, Mn, Mo, Ni, Rb, Sb, Sc, Se, Sr, Ta, Th, U, V, W, Zn, La, Ce, Nd, Sm, Eu, Gd, Tb, Dy, Yb, and Lu, were determined by instrumental neutron activation analysis (INAA) for samples of elemental sulfur and soil samples from selected depths adjacent to a large elemental sulfur stockpile. The objective was to determine the total content of trace elements and examine their redistribution within surficial till material influenced by extreme acidity resulting from the oxidation of elemental sulfur. The elemental sulfur did not contain detectable (by INAA) quantities of other elements to contribute to soil contamination. Elements mobilized within the acidified section were derived solely from the parent till. A Fe-rich indurated layer that formed at the interface of the acidified and calcareous layers acted as a scavenger for As, Co, and Ga. Formation of aqueous

sulfate complexes probably inhibited attenuation of Mn, Sc, Th, U, Zn and rare earth elements. Barium and Hf were enriched in the acidified material while B, Rb, Cs, Sb, Ta, and V showed no evidence of redistribution. Mercury uniquely volatilized from the soil surface.

(720) Arp, P. A., T. Oja, et al. (1996). Calculating critical S and N loads and current exceedances for upland forests in southern Ontario, Canada. Air pollution and multiple stresses 26(4): 696-709.
A steady-stage mass-balance model was used to calculate critical loads of S and N deposition for maintaining acceptable long-term acidity levels within upland forests in southern Ontario. Preliminary estimates about critical S and N loads were obtained using existing information about soils, vegetation and atmospheric ion deposition from 12 forest sites, all located within provincial parks or conservation areas. The following were considered: wet atmospheric deposition of all major cations and anions; availability for plant uptake of N, Ca, Mg, and K in the rooting space of each soil; nutrient uptake and storage in the growing woody biomass of the forest stands; estimates of soil weathering; and mean annual air temperature, precipitation, and evapotranspiration. From this, regional isopleth maps were generated to depict the following: (1) current deposition patterns; (2) critical acidification loads and their current exceedances (or nonexceedances) for two acidification effects criteria for soil solutions, namely (i) acceptable Al concentrations and (ii) acceptable Al to base cation concentration ratios; and (3) critical N-eutrophication loads and their current exceedances for acceptable levels of NO3-N concentrations in soil solutions. It was found that the northern part of the study area (part of the Canadian Shield) is currently subjected to atmospheric S and N deposition in excess of critical loads. This sensitivity to acid precipitation is, as calculated, primarily due to shallow and weathering-resistant soils and soil parent materials (mostly granitic). The middle portion of the study area is calculated to receive N slightly in excess of the N eutrophication limit. Considerable co-deposition of base cations (Ca, Mg, K) in the middle and southern part of the study area alleviates some of the atmospheric acidification stress. This stress is further neutralized by the soils and bedrock of this region (predominantly calcareous).

(721) Rajan, S. V. G., R. S. Murthy, et al. (1972). A review of recent work on foliar application of plant nutrients to crops. Indian Journal of Agricultural Chemistry 5(1): Suppl., 1-7.
In this review, it is shown that the same rate of fertilizer gives greater increases in crop yields when applied as a foliar spray than when applied to the soil. The effectiveness of fertilizers is conditioned by the rate of uptake and subsequent mobility of the nutrient involved. The foliar application of nutrients is more beneficial when applied as a supplement to rather than as a substitute for soil applications of fertilizers.

(722) Lukewille, A., V. Malessa, et al. (1995). Measured and modelled retention of inorganic sulfur in soils and subsoils (Harz Mountains, Germany). Water, Air, and Soil Pollution 85(2): 683-688.
Atmospheric deposition of inorganic sulfur (S) was analysed in forest soils at Sosemulde (Harz Mountains) in samples from 5-240 cm depth. Most sulfate (SO4) accumulated at _ 30-60 cm depth: 8.5-9.5 mmolc/kg. Large amounts can also be retained at >100 cm depth. To assess changes in SO4 dynamics in time, adsorption isotherms have been included in several process-oriented models, e.g. MAGIC. The Lange Bramke (LB) Model is a catchment model containing solubility products for the hydroxosulfate minerals jurbanite and alunite. By reconstructing the long-term acidification history (140 years) both models were successfully calibrated to a 14-year deposition, soil and streamwater data set at Lange Bramke catchment (Harz Mountains). According to MAGIC the present accumulation of SO4 in 0-80 cm is 8.7 mmolc/kg, while according to the LB-Model 10.2 mmolc/kg are stored as jurbanite. Both models predicted 4.5 mmolc SO4/kg in the subsoil layer, retained as alunite in the LB Model. These values correspond to the amounts measured in soil and subsoil samples at Sosemulde, respectively. However, for future scenarios with decreasing S inputs the models show different developments in SO4 concentrations. Changes in MAGIC are gradual whereas the LB model predicts stepwise decreasing SO4 values as soon as previously stored hydroxosulfates are fully dissolved. Such concentration 'jumps' have not been observed.

(723) Ghani, A., R. G. McLaren, et al. (1992). Sulphur mineralisation and transformations in soils as influenced by additions of carbon, nitrogen and sulphur. Soil Biol Biochem 24(4): 331-341.
The mineralisation of soil organic sulphur was examined for two soils using an open incubation system. Combinations of glucose-carbon, nitrate-nitrogen and sulphate-S were added to the incubated soils at regular intervals to examine the effects of these nutrients on S mineralisation. Soil microbial activity was monitored by CO2 evolution from the incubated samples. At the end of the 14-week incubation, the incubated soils were analysed to determine the sources of S mineralised during the incubation. In both soils, the addition of C, N and S had a considerable effect on S mineralisation. Additions of C or S decreased S mineralisation whereas N additions slightly enhanced mineralisation. The mineralised S appeared to be derived almost exclusively from C-bonded forms of soil organic S. In both soils, there were substantial increases in hydriodic acid (HI)-reducible forms of S during the incubation. Additions of C, N and S influenced the amounts of S mineralised or transformed from or to C-bonded and HI-reducible forms of soil organic S. The results from this study are discussed in relation to the dichotomous model of S cycling in soil as proposed by McGill and Cole (Geoderma, 26, 267-286, 1981). In some respects, the S mineralisation data appeared to support the model. However, in relation to the source of mineralised S, there were large differences between what the model would predict for certain treatments and what was actually observed. This was particularly true with regard to the transformations of HI-reducible forms of organic S.

(724) Badiger, M. K., R. Michael, et al. (1985). Studies on some aspects of soil sulphur and response of sunflower to sulphur application. J Indian Soc Soil Sci 33(1): 73-77.
Typical acid soils (Inceptisols) mostly from coastal areas in Karnataka were characterised by the presence of different forms of sulphur. Significant relationships existed between various fractions and total sulphur. The sulphur retention capacities were high in those soils dominated by kaolinitic clay minerals associated with low pH. While the increase in seed yield of sunflower due to graded applications of sulphur was not significant, the contents of amino acids, cystine and methionine were significantly increased at the 10 and 20 ppm S levels. Sulphur application increased the concentration of sulphate and heat-soluble forms of S in the soil after harvest of the sunflower crop.

(725) Berndt, W. L. and J. M. Vargas, Jr. (1992). Elemental sulfur lowers redox potential and produces sulfide in putting green sand. HortScience 27(11): 1188-1190.
Biological production of sulfide (S2-) in soil has been reported on system redox potential and on the concentrations of available sulfate (SO4(-2)) and organic carbon (OC). The purpose of this laboratory study was to determine whether elemental sulfur (S(0)) could influence redox potential and S2- production in sand used to

construct putting greens. Treatment with S(0) depressed redox potential as pe + pH, and stimulated accumulation of both free H2S and acid-soluble S2-. Organic carbon as lactate (C3H5O3Na) intensified the effects of S(0), primarily by influencing pH. Thus, S(0) application could induce anaerobiosis and subsequently affect turf quality by heightening production of free hydrogen sulfide (H2S). It could also contribute to S2- accumulation possibly expressed as a black layer or blackening of the root zone.

(726) Ruter, J. M. (1998). Pot-in-pot production and cyclic irrigation influence growth and irrigation efficiency of 'Okame' cherries. Journal of Environmental Horticulture 16(3): 159-162.
A study was conducted with Prunus X incamp 'Okame' to evaluate the effects of a pot-in-pot production system (PIP) compared to a conventional above-ground system (CAG) and cyclic irrigation on plant growth and water loss. Plants were grown in 7 (26 liter) containers with a pinebark:sand (8:1 by vol) substrate. Cyclic irrigation provided the same total volume of water, but was applied one, three, or four times per day. Final plant height and stem diameter, shoot and root dry weight, total biomass, and root:shoot ratio all increased for plants grown pot-in-pot compared to above-ground. Multiple irrigation cycles increased stem diameter, shoot dry weight and total biomass compared to a single irrigation application. Multiple irrigation cycles also decreased the root:shoot ratio. Mean daily water loss (plant transpiration + evaporative loss from the substrate) was influenced by production system, irrigation, and date. Mean daily water loss was 30% higher for pot-in-pot grown plants compared to above-ground. Cyclic irrigation resulted in a two-fold decrease in average leachate volume and a 27% increase in overall irrigation application efficiency compared to a single application. Production system had no affect on leachate volume or irrigation application efficiency. Substrate pH increased when cyclic irrigation was used. Production system and irrigation had no affect on soluble salts. Nitrate-N concentrations were less in the leachate of plants grown pot-in-pot compared to above-ground.

(727) Appleton, B. L. and S. C. French (2000). Weed suppression for container-grown willow oak using copper-treated fabric disks. HortTechnology 10(1): 204-206.
A commercially available copper-treated disk was evaluated for its effect on weed suppression for container-grown willow oak (Quercus phellos L.). No weeds grew in containers where disks were used. All trees grown without disks or preemergence herbicide were dead within 6 months. Top dry weights were greater for trees grown with disks or preemergence herbicide, but root dry weights were not different.

(728) Bhardwaj, K. K. R. and I. P. Abrol (1978). Nitrogen management in alkali soils. Nitrogen Assimilation and Crop Productivity National Symposium: Hissar, India, October 1976 (Sen, S.P.
High soil pH, poor soil permeability and low organic matter content greatly influence the management of nitrogen fertilizers on these soils. On alkali soils, the nitrogen requirements for optimum yields are usually higher than for crops grown on non-sodic soils. Fertilizer efficiency is greatly influenced by adverse conditions, which modify the nature and extent of the transformations. Ammonium fertilizers are more effective than those containing nitrate nitrogen. Foliar sprays of urea were superior to soil applications. Nitrogen fixation by leguminous crops is limited by the soil's lack of effective strains of root nodule bacteria.

(729) Ruter, J. M. (1992). Leachate nutrient content and growth of two hollies as influenced by controlled release fertilizers. Journal of Environmental Horticulture 10(3): 162 - 166.
An experiment was conducted to evaluate the effects of fertilizer source, rate of application, and method of application on the release of nutrients over time using the pour-through method of nutrient extraction and to determine the growth response of liners of the landscaping hollies Ilex cornuta cv. Burfordii and the hybrid cultivar Nellie R. Stevens to different multicoated controlled release fertilizers (CRF). Depending on the rate of application used, Osmocote 17N-3P-9.9K, Sierrablen 17N-3P-8.3K and High-N 24N-1.7P-5.8K provided adequate concentrations of nutrients for a minimum of 90 days after treatment. Fertilizer source had no effect on the growth of either holly used in this study. Good growth of both cultivars was obtained at the rate of 1.5 kg N/m3. Linear relationships between NO3-N and electrical conductivity using the pour-through method were established for Burfordii (NO3-N = 414 (EC)) and Nellie R. Stevens (NO3-N = -11.4 + 425 (EC)). Results of this study indicate that the nutrient sufficiency values for liquid fertilization programmes with the pour-through method need to be adjusted for use with multicoated CRFs.

(730) Karam, N. S., A. X. Niemiera, et al. (1994). Cyclic sprinkler irrigation of container substrate affects water distribution and marigold growth. Journal of Environmental Horticulture 12(4): 208-211.
Two experiments were conducted to determine how cyclic sprinkler irrigation (daily water allotment applied in more than one application) influenced water distribution and leaching, and Tagetes erecta growth in a pine bark (PB) or a PB:sand (S) substrate. T. erecta cv. Apollo were grown in PB-filled 3.8-litre containers. Substrate was allowed to dry via evapotranspiration (ET) to targeted pre-irrigation substrate water contents (PSWC) and respective ET volumes were applied as a single application (continuous) or by multiple applications (cyclic irrigation) via a simulated sprinkler irrigation system; leachates were collected. In the first experiment, the influences of irrigation method, continuous and cyclic irrigation, on water distribution in the top, middle and bottom substrate (9:1 pine bark to sand, by volume) sections were investigated. Two hundred and seventy-five ml were applied continuously or cyclically (three 92-ml allotments with 1-h interval between applications) to containers at 84% of container capacity (CC). In the second experiment, T. erecta were grown in a growth chamber for 3 weeks and received 12 irrigations. In each irrigation, a complete nutrient solution was applied continuously or cyclically (3 applications each of one-third of the total volume with 1 h between applications). Substrate solution N concentration (via pour-through method), leachate N, and plant growth were measured. In the first experiment, gravimetric water contents of top and middle substrate sections were similar, whereas the water content of the bottom section was higher with cyclic than with continuous irrigation. In the second experiment, root DW was 43% higher and plant N concentration was 0.7% higher (absolute basis) with cyclic than with continuous irrigation. Irrigation method had no influence on shoot FW or DW or substrate solution and leachate NO3-N and NH4-N concentrations. However, total N leached was 43% higher with continuous than with cyclic irrigation. These results demonstrate that cyclic irrigation increased root N concentration and root growth without a toxic accumulation of N in the substrate solution.

(731) Tyler, H. H., S. L. Warren, et al. (1996). Cyclic irrigation increases irrigation application efficiency and decreases ammonium losses. Journal of Environmental Horticulture 14(4): 194-198.
Cyclic irrigation using pressure compensated drip emitters was evaluated for irrigation application efficiency, nutrient efficacy, and plant growth. The experiment, a RCBD with four replications was conducted in a simulated nursery using high volumes of irrigation which are common in container-grown ornamental nurseries in the southeastern United States. A container-grown plant production area, subdivided into 16 separate plots, allowed

for the collection of all irrigation water leaving each plot. Rudbeckia fulgida cv. Goldsturm and Cotoneaster dammeri cv. Skogholm plants were potted into 3.8-litre containers in a pine bark:sand substrate (8:1 by vol) and irrigated with either 900 ml of water applied once a day, 450 ml applied in 2 cycles, 300 ml applied in 3 cycles, or 150 ml applied in 6 cycles. A cycle consisted of a 1-hour rest interval between each irrigation allotment. At 08.00 h daily, the volume of effluent from each plot was measured and a sub-sample of the effluent was analysed for NO3-N, NH4-N, and P. Cycled irrigation reduced the volume of effluent, increased irrigation application efficiency and decreased total NH4-N losses compared with applying 900 ml once a day. There were no significant differences between cycled irrigation treatments in effluent volume or irrigation application efficiency. However, NH4-N losses were greater when 450 ml was applied in 2 cycles than when 300 ml or 150 ml were applied in 3 or 6 cycles, respectively. Irrigation treatments did not affect NO3 or P losses. Irrigation application efficiency over the course of the experiment averaged 0.52 for cyclic irrigation applications, a 38% improvement over the 900 ml standard application. Depending on irrigation treatment, 89-104% of the 3.0 g N applied was recovered. N efficiency averaged 89% and 88% for C. dammeri and R. fulgida, respectively. Of the 0.34 g P applied, 43.4% was recovered. P efficiency averaged 29% for both species. Growth, nutrient concentration, and nutrient content were not affected by irrigation treatments in either species.

(732) **Warren, S. L., T. E. Bilderback, et al. (1995). Efficacy of three nitrogen and phosphorus sources in container-grown azalea production. Journal of Environmental Horticulture 13(3): 147-151.**
Root stem cuttings of Sunglow azalea (Rhododendron sp.) were potted into 3.8-litre (<hash>1) containers with a pine bark:sand (6:1 by volume) substrate and topdressed with 3.5 g N per container using resin-coated NH4NO3 and P (Osmocote 18N-2.6P-10K), urea and sulfur-coated P (Woodace 20N-1.8P-9.1K) or composted turkey litter (CTL; Sustane 5N-0.9P-3.3K). A container-grown plant production area was constructed and subdivided into 9 separate plots, 7.6 X 1.8 m, with a 2% slope and lined with black plastic. At 05.00 h daily, 1.3 cm of water was applied by overhead irrigation at a rate of 1.6 cm/h resulting in a leaching fraction of approximately 0.1-0.2. All effluent was collected individually from each plot. At 08.00 h daily, the volume of effluent was measured and sub-sampled for analysis of NO3-N, NH4-N and P. After 100 days, 13, 12 and 9% of the N applied was recovered in the effluent from containers fertilized with resin-coated NH4NO3, urea, and CTL, respectively. Of the P applied, 8, 217 and 15% was recovered in the effluent with resin-coated P, sulfur-coated P, and CTL, respectively. Resin-coated NH4NO3 and urea produced greater shoot growth and higher shoot N content than CTL. Shoot and root P contents were greatest with resin-coated P. N efficiency (defined as amount of N absorbed by the plant divided by amount of N found in effluent+plant) was highest for resin-coated NH4NO3 and urea (56%); P efficiency was highest (43%) for resin-coated P.

(733) **Ruter, J. M. (1998). Fertilizer rate and pot-in-pot production increase growth of Heritage river birch. Journal of Environmental Horticulture 16(3): 135-138.**
A study was conducted to compare the effects of three fertilizer rates (High N Southern Formula, 23N-1.7P-6.6K (23-4-8) at 1.3, 1.7, and 2.0 kg N/m3 (2.2, 2.8, and 3.4 lb N/yd3)) and two production systems (pot-in-pot (PIP) or conventional above-ground (CAG)) on the growth of Heritage river birch (Betula nigra L. 'Cully') in 26 liter (7) containers. Plants grown PIP had greater shoot dry weight (20%), root dry weight (31%), total biomass (27%) and root:shoot ratios (12%). Increasing fertilizer rates increased shoot dry weights but decreased root:shoot ratios. Rate of fertilizer application influenced foliar Mg, Zn, and Fe while production system had no effect. The foliar P:Zn ratio increased linearly as rate of fertilizer increased. Soluble salts and NO3-N in the leachate increased linearly as rate of fertilizer increased at 15 and 60 days after application (DAA), whereas the response was curvilinear at 120 DAA. When different, nutrient concentrations in the leachate were greater for plants grown CAG. Fertilizer longevity based on prill analysis was greater when the PIP system was used, presumably due to lower substrate temperatures during the experimental period.

(734) **Gilliam, C. H., G. J. Keever, et al. (1992). Postemergence applied herbicides for use on ornamental grasses. Journal of Environmental Horticulture 10(3): 136-139.**
Postemergence-applied, grass-active herbicides registered for use in the landscape were applied over-the-top of four ornamental grass species to evaluate tolerance in 1990 and 1991. All herbicides caused some injury to all grass species. Growth indices of dwarf fountain grass (Pennisetum alopecuroides L.K. Spreng. 'Hameln)' and pampas grass (Cortaderia selloana Schult. & Schult. f. Asch & Graebn. 'Rosea') treated with the low rate of Poast (sethoxydim) was similar to that of the nontreated plants in both years. Acclaim (fenoxaprop-ethyl) caused less injury to purple maiden grass (Miscanthus sinensis Anderss. 'Purpurescens') and maiden gras (M. sinensis Anderss 'Gracillimus') than Poast and Fusilade 2000 (fluazifop). Both Acclaim rates resulted in similar growth indices to that of nontreated plants. Flowering was reduced in three of the four grass species with all grass active herbicide treatments; the fourth species did not flower.

(735) **Sibley, J. L., J. M. Ruter, et al. (1998). Differences in growth of container-grown red maple cultivars in different hardiness zones. Journal of Environmental Horticulture 16(3): 130-134.**
Growth of eight container-grown red maple cultivars was evaluated at four locations under dissimilar environmental conditions/hardiness zones in Georgia and Alabama for two years. Rooted cuttings and tissue cultured plantlets were planted in 3 (9.1 liter) containers in one location in the same substrate in April 1995. Trees were transported the second week of June to Blairsville, GA; Muscle Shoals, AL; Auburn, AL; and Tifton, GA in USDA hardiness zones 6b, 7a, 8a, and 8a, respectively. Dormant trees were transplanted to 10 (38 liter) containers the second week of December 1995. At the conclusion of the study, December 1996, growth differed by location and cultivar. Height and stem diameter increase, and root and stem dry weights were greatest at the two Alabama locations for most cultivars and were least at the two Georgia locations. Root:shoot ratios were greatest at the two Georgia locations, an indication of increased carbon partitioning of photoassimilates to roots over stems under dryer growing conditions. Irrigation rates and different environmental conditions among locations have a significant impact on growth response of container-grown red maple cultivars.

(736) **Shiflett, M. C., A. X. Niemiera, et al. (1994). Mid-season reapplication of controlled release fertilizers affect 'Helleri' holly growth and N content of substrate solution and effluent. Journal of Environmental Horticulture 12(4): 181-186.**
Container-grown Ilex crenata cv. Helleri liners were initially fertilized (7 Mar.) with an 8- to 9-month controlled release fertilizer (CRF) Osmocote 18N-2.6P-9.9K, or a 12- to 24-month CRF, Osmocote 17N-3.1P-9.9K. A subset of plants received a second CRF application (half rate) of the respective Osmocote formulations on 19 July, 2 Aug. or 16 Aug. In addition, 12 plants received a water soluble fertilizer solution (WSF) with each irrigation starting on 19 July. All effluent was collected and analysed for N. Substrate solution N and electrical conductivity

(EC) levels (using the pour-through method) and foliar N concentrations were determined every 2 weeks. Throughout the experiment, plants were irrigated with an amount of water that resulted in a leaching fraction (LF) of _ 0.25. Plant width, determined on 1 Nov., was greater in all fertilizer treatments than in the control. However, in terms of commercial size grades, plants of all treatments were in the same grade. Thus, there was no economic advantage to reapplying CRF. It is concluded that CRF reapplication was not necessary when substrate solution N and foliar N values were _20 mg N/litre and _2.3%, respectively. When irrigated to give a LF of 0.2, the mid-season CRF application increased the amount of N lost from containers by 42% compared with a single, early season CRF application.

(737) Fare, D. C., C. H. Gilliam, et al. (1994). Nurseries can preserve water quality with cyclic irrigation. Highlights agr res 41(3): 8.

(738) Schoenemann, J. (1993). Use field tests to get nitrogen just right. American Vegetable Grower(June): 22 - 23.

(739) Hochmuth, G. (1993). Hard figures for petiole sap testing. American Vegetable Grower(December): 62 - 63.

(740) Roach, B. T. and Egan (1990). Sampling and diagnostic procedures for testing sugarcane resistance to ratoon stunting disease by phase contrast microscopy. Proceedings of the 1990 conference of the Australian Society of Sugar Cane Technologists held at Townsville 1-4 May: 111-119.
The concn of Clavibacter xyli subsp. xyli in xylem sap of basal stalk tissue increased progressively to a peak in May, even in crops of differing ages. Bacterial concn then declined in mature field-grown crops, but appeared to remain around the May levels in immature and pot-grown cane. May thus appears to be an appropriate time for quantitative assessment of RSD populations in resistance trials. Cane grown in 15-litre pots and subject to intermittent drought stress had consistently higher populations (av. >twice) of RSD bacteria than field-grown cane of the same clones at the same age. Estimates of bacterial populations in xylem extracts from basal tissue of single stalks randomly sampled from cane plots show high sampling errors. However, in a comparison of 3 clones of differing RSD susceptibility, there was little overlap in individual counts between resistance classes, and mean counts for the 3 clones were significantly different. In general, it is preferable to sample more stalks from a plot than more sections from a single stalk, which in turn is preferable to examining >1 slide prepared from a single extract. Development of a centrifuge technique of xylem sap extraction allows the preparation of a combined extract of several stalks by centrifuging a number of stalk sections in the same tube. Phase contrast microscopy appears to be an appropriate diagnostic technique for quantitative estimation of RSD infection, assessed as bacterial concn following inoculation, in trials to determine clonal resistance.

(741) Gerwing, J. (1986). Soils. Field facts : soils, insects, diseases, weeds, crops PREVIOUS TITLE: Pest o gram. 3(11): 1 - 3.

(742) Dahnke, W. C. e. (1975). Recommended chemical soil test procedures for the North Central Region. Bull-Dep-Agric-Econ-N-D-Agric-Exp-Stn-N-D-State-Univ-Agric-Appl-Sci,(499): 1 - 23.

(743) Bangar, A. R. (1984). A quick procedure for correlation of phosphorus soil test with plant response. J Indian Soc Soil Sci 32(4): 761-762.

(744) Lancaster, M. E., J. M. Davis, et al. (1998). A continuously diluting injector for applying fertilizer to experimental and demonstration plots. HortTechnology 8(2): 221-224.
Small-scale research plots and demonstrations of fertilizer application through a drip-irrigation system have inherent characteristics that make using commercial fertilizer injection systems difficult. Uniform fertilizer application, without excessive water, is essential for meaningful results in these small-scale, rate-specific studies. An inexpensive, easy to build, continuously diluting fertilizer injector is described. This injection system was reliable and provided uniform application under the confines of a low flow rate.

(745) Dellen, J. V. (1998). The green machines. American Nurseryman(December 1): 24 - 26, 28, 30.
Facing diminishing labor pool and increasing labor costs, the green industry continues to come up with its own labor-saving equipment

(746) Reeser, P. W. (1998). Disinfection for plant protection. American Nurseryman(June 15): 52 - 55.
A research study shows that disinfecting recycled irrigation water with chlorine or ozone may reduce the presence of plant pathogens

(747) Anon. (1997). Researchers prepare to introduce new irrigation system. American Nurseryman(June 15): 14.

(748) Pill, W. G. (1997). Filling the voids. American Nurseryman(June 15): 30 - 32, 34, 36 - 37.
Using amandments to alter landscape soils or container media ensures that roots receive adequate water and air. Her are some ideas on how to achieve that goal.

(749) Suttle, W. (1998). Weeding out costly controls. American Nurseryman(October 15): 24 - 29.
Nursery owners can alternate between hand-weeding and herbicides to effectively and efficiently eradicate weeds

(750) Larson, R. A. (1998). Propagating woody plants by seed. American Nurseryman(October 1): 39 - 43.
Here's a guide that can help growers germinate seed of woody plants common to the nursery

(751) Bilderback, T. and R. E. Bir (1998). Best of the best. American Nurseryman(October 1): 56 - 62, 64.
Best management practices for irrigation can help nursery professionals achieve success

(752) Gioia, V. G. (1998). Trademark tactics. American Nurseryman(October 1): 91 - 97.
Trademarks may be the best and least expensive way to protect your new plant varieties from being marketed and sold by competitors

(753) Klingaman, G. (1996). On-the-fly fertigation. American Nurseryman(July 15): 70 - 72, 74 - 77.
You can select the right fertilizer injector for your growing operation by understanding how an injection system works and how injectors differ.

(754) Brothers, C. T. and R. M. Lapierre (1998). Coming to a root system near ou. American Nurseryman(November 1): 89 - 93.
A new chemical technology shows promise for controlling container-plant root growth

(755) Swanson, B. T. (1998). Extensive media coverage. American Nurseryman(October 1): 30 - 34.
Container media should have the appropriate porosity and water

retention for optimum plant growth and health

(756) Englert, J. M., L. H. Fuchigami, et al. (1993). Bare-root basics. Am Nurseryman 177(4): 56-58, 60-61.
How to handle bare-root trees and shrubs after harvesting

(757) Cabrera, R. I. (1997). Let the nutrients flow... slowly. American Nurseryman 185(5): 32 - 37.
Slow-release and controlled-release fertilizers deliver nutrients at varying rates, and knowing what affects those rates can help growers produce healthier container plants

(758) Gainer, B. L. (1998). Containing root problems. American Nurseryman(June 15): 34 - 36, 38 - 39.
Growers of containerized woody ornamentals discuss the methods that help them develop root systems they can be proud of

(759) Anon. (1998). Definition proposed for premium potting soil. American Nurseryman(October 15): 12, 19.
The National Bark & Soil Producers Association (NBSPA) has developed a definition of premium soil products for possible use as an industry standard

(760) Lumis, G., P. Purvis, et al. (1996). Cover crops for nursery tree production. Landscape Trades(September): 11 - 13, 42.
Permanent cover crops of perennial grasses and/or legumes are often used in horticultural crop produc-tion. Cover crops grown between rows of orchard or nursery trees help to reduce soil erosion (3,4), water and sediment run-off (3), weeds and herbicide inputs (4) and soil tem-perature (8). Also, cover crops increase soil organic matter (4,8), soil moisture infiltration and retention (5), and may increase crop plant survival (7) as well as crop nutrient content (10). Cover crops also enable equipment to move more easily during moist spring and fall digging. Despite these potential ben-efits, growing permanent cover crops between rows of nursery stock is not a common practice. Possible concerns with cover crops are competition for water and nutrients as well as their being a host for rodents and crop damag-ing insects.

The purpose of this study was to determine the effect of three permanent cover crops on the growth of several nursery tree species. Also, we examined the influence of the cover crops on soil pH and organic matter.

(761) Faulkner, S. P. (1997). The modified Steiner solution: A complete nutrient system. The Growing Edge: 43 - 49.

(762) Gilliam, C. H. and E. M. Smith (1980). How and when to fertilize container nursery stock. American Nurseryman 151(2): 7, 117 - 127.
The volume of medium in a container is limited. Therefore it is necessary to develop a detailed nutritional program to produce satisfactory plant groth. Nurseries fertilize via several methods, usually split into two categories: Fertilizing done before planting and that done afterwards

(763) Shroeder, B. (1996). Grass for fruit orchards. Shelterbelt News(Fall).

(764) Watanabe, F. S. and S. R. Olsen (1965). Test of an ascorbic acid method for determining phosphorus in water and NaHCO3 extracts from soil. Proceedings from the Soil Science Society: 677-678.
Murphy and Riley proposed use of a single reagent for determining P. The method was found to be accurate for determining P in soil extracts. This method is based on reduction of the ammonium molybdipbosphate complex by ascorbic acid in the presence of antimony. The color produced is stable for 24 hours. It is less subject to interfering substances than are methods involving reduction by SnCl2.

(765) Mapplebeck, L. R. and J. Morton (1996). Evaluation of fertilizer program on container-grown Woodwardii globe cedar. Biannual Report (1994 - 1996): Nova Scotia Agricultural College, Dept. of Plant Science: 97 - 99.
Nutricote products evaluated in this experiment were superior to Woodace products. Topdressing is, in general, superior to incorporating the fertilizer. Fertilizer product, rate of application and application method not only influence plant growth but are also correlated to levels of nutrients leaching out of the containers. These are not only wasted but can cause environmental pollution. A grower should choose the fertilizer program that grows the fastest plants with the least fertilizer wastage. In this experiment this would be topdressed Nutricote Total 18-6-8 Type 140 at 1 kg N/m3 mix. Buying a cheaper fertilizer; i.e., Woodace products and/or applying excessive levels of any fertilizer, will, in the end, simply cost more and not less.

(766) Kudjo Dzantor, E. (1991). Microbial responses to large concentrations of herbicides in soil. Environmental Toxicology and Chemistry 10(5): 649-655.
A mixture of a silt and silty clay loam soil was treated with simulated spills (10 000 mg/kg) of alachlor alone or as a mixture with atrazine, metolachlor, and trifluralin or with the same combinations of herbicides at a rate of 10 mg/kg, which is typical of normal farming practices. Simulated spills initially inhibited bacteria, but after 7 days bacterial numbers had recovered to levels similar to those in untreated controls. Fungal populations were drastically reduced after 1 day and became undetectable after 7 and 21 days of incubation in the mixed herbicide and alachlor-only treatments, resp. Dehydrogenase activities were severely depressed after 1 day in both high-level herbicide treatments and did not recover after 125 days. Esterase activities were depressed in soils receiving the mixture of herbicides but were generally unaffected in the alachlor-only treatment. Normally applied concn did not have any pronounced effect on bacterial and fungal populations or on the activities of soil dehydrogenase and esterase. At 10 mg/kg, all the herbicides degraded by 80 to 90% within 1 year; there was no difference between degradation of alachlor applied alone or as a herbicide mixture. With high concn of herbicides, degradation was negligible after 1 year of incubation.

(767) Rose, M. A., M. Rose, et al. (1999). Fertilizer concentration and moisture tension affect growth and foliar N, P, and K contents of two woody ornamentals. HortScience 34(2): 246-250.
Crabapple (Malus xzumi (Rehd.) 'Calocarpa'] and maple (Acer xfreemanii E. Murray 'Jeffersred') trees were grown in containers from 22 June to 3 Oct. with three fertilizer concentrations (50, 100, and 200 mg(.)L(-1) N) and two levels of moisture tension in the medium [low setpoint (moist) = 5 kPa and high setpoint (dry) = 18 kPa]. Whole-plant growth was enhanced more by minimizing water stress than by increasing fertilizer concentration. Shoot length and whole-plant dry weight were greater (>29% for crabapple and >90% for maple) in low tension treatments (low water stress) but were unaffected by fertilizer concentration. Moisture tension also had a dominant effect on dry-weight allocation to leaves, stems, and roots. In contrast, foliar nutrient concentrations increased with fertilizer concentration but were affected to a lesser degree by moisture tension. Seasonal patterns in biomass allocation were little affected by treatments; the largest proportions of leaf and root biomass accumulated during summer and fall, respectively.

(768) Andersen, P. C., F. M. Rhoads, et al. (1999). Relationships of nitrogenous compounds in petiole sap of tomato to nitrogen fertilization and the value of these compounds as a predictor of yield. HortScience 34(2): 254-258.
'Colonial' tomato (Lycopersicon esculentum Mill.) plants were grown on raised beds with black polyethylene mulch, drip irrigation, and preplant-N rates of 0, 67, 134, 202, or 269 kg(.)ha(-1). Petiole sap was collected 7 and 13 weeks after transplanting. Concentrations of NO(3)-N, free amino acids, total amino acids, and total-N (the sum of NO(3)-N and amino acid-N) were examined as functions of the rate of N fertilization. Also, each of these compounds was used as an independent variable as a predictor of fruit yield. Seven weeks after planting, the concentrations of NO(3)-N and 15 of 18 of the free amino acids were correlated with the rate of N fertilization, but concentrations of bound or total amino acids were not. The amount of NO(3)-N accounted for 37% of the total-N in the 0 kg(.)ha(-1) treatment, and up to 83% in the 202 kg(.)ha(-1) treatment. NO(3)-N was highly correlated with total-N for both nonhydrolyzed and hydrolyzed sap (R(2) = 0.98). Thirteen weeks after transplanting, neither the concentration of NO(3)-N nor that of amino acids, other than asparagine, glutamine, and proline, were significantly related to the rate of N fertilization. On both dates, concentrations of glutamine plus glutamic acid were correlated with rate of N fertilization whether expressed as absolute values or as percentage values. N fertilization rate and the concentration of NO(3)-N or total-N were related to total fruit yield (R(2) = 0.69 to 0.74), and marketable fruit yield (R(2) = 0.78 to 0.82). N-fertilization rate and petiole sap concentrations of NO(3)-N or total-N were also correlated with the N contained in total or marketable yield. Petiole sap variables measured.

(769) Davis, T. (1995). Fertilization program. Greenhouse Management and Production(March): 45 - 48.

(770) Appleton, B. L. (1996). Examine ways to wrap root balls. Nursery Management and Production(March): 52 - 52.

(771) Cuny, H. (1996). Feed crops without contaminating nature. Nursery Management 1996(March): 47 - 49.
Best management practices help you reduce the risk of fertilizer runoff

(772) Martin, C. (1996). Fertilizer placement in containers affects growth in hot climates. Nursery Management and Production(July): 23.

(773) Appleton, B. L. (1996). How to avoid end-of-the-year yellowed leaves. Nursery Management and Production(July): 69 - 71.

(774) Million, J. B., J. E. Barrett, et al. (1998). Influence of pine bark on the efficacy of different growth retardants applied as a drench. HortScience 33(6): 1030-1031.
Dendranthema xgrandiflorum (Ramat.) were grown in either a peat-based or pine bark-based medium and drenched with growth retardants at a range of concentrations to generate dose:response curves. The effect of ancymidol, paclobutrazol, and uniconazole on stem elongation was less in the pine bark-based than in the peat-based medium. Generally, the concentrations required to achieve the same response were 3- to 4- fold as high in the pine bark-based medium as in the peat-based medium. However, chlormequat was slightly more active in the pine bark-based medium than in the peat-based medium.

(775) Harrington, J. T. and J. T. Fisher (1999). Nursery and landscape performance of ornamental junipers in the southern Rocky Mountains. HortTechnology 9(1): 40-44.
Supplying landscape plants for expanding urban centres in the southern Rocky Mountains in the USA provides a solution to limited-resource producers wishing to convert from traditional agricultural crops to higher value horticultural crops in this region. Thirty-five cultivars of ornamental junipers (Juniperus sp.) were planted in an abandoned agricultural field in Mora, New Mexico, USA, to evaluate their suitability for nursery production in this region. The plantings were measured after 4 years, and cultivars were ranked for nursery suitability. The planting was then grown for an additional 16 years to examine landscape performance. Nineteen cultivars were considered suitable for nursery production with 5 cultivars being highly recommended based on survival and growth. Twenty-five of the cultivars were considered suitable for landscape use in the foothill region of the southern Rocky Mountains based on the 20-year measurements. Nine cultivars were classified as highly recommended.

(776) Kallsen, C. (1999). The effect of timing of the final seasonal nitrogen fertigation on early fruit maturity, fruit diameter, and leaf nitrogen on navel oranges. HortTechnology 9(1): 51-53.
In trials with Fisher Navel orange trees in a commercial orange grove in the southern San Joaquin Valley, California, USA, the total seasonal allocation of N fertilizer was applied by _1 May, 1 June, 1 July and 1 August 1996 and 1997. The source of N was a liquid calcium ammonium nitrate injected through the irrigation system. No significant treatment differences in soluble solids concentration, titratable acidity, the ratio of soluble solids concentration to titratable acidity, percent juice, fruit colour or fruit diameter were detected in fruits sampled in October. Similarly, in September, no significant differences in leaf N were found among treatments. These results do not support the hypothesis that applying the total seasonal application of N early in the season results in earlier fruit maturity or larger fruit size, at least not for trees that have leaf N in the optimum range.

(777) Ebel, R. C., A. Caylor, et al. (1999). Effect of ethrel on bloom delay, harvest date, and fruit weight of 'empress' peach. HortTechnology 9(1): 65-67.
In trials in central Alabama, USA, trees of the early maturing peach cultivar Empress were sprayed with 0, 100 or 200 ppm (mg/litre) Ethrel ethephon] in 1994, 1995 and 1996 to determine if bloom delay by Ethrel reduces fruit weight at harvest. Trees were hand-thinned at 0 or 3 weeks after full bloom to equalize crop load across Ethrel treatments and to determine if any reduction in fruit weight at harvest by Ethrel could be compensated for with earlier thinning. Ethrel at 200 ppm delayed bloom by 3, 0 and 7 days in 1994, 1996 and 1997, respectively. Despite bloom delay, Ethrel did not delay harvest or reduce fruit weight. Thus, earlier hand thinning was not necessary. Ethrel did not affect blossom density and was not phytotoxic to vegetative or reproductive organs. The results indicate that even with the shorter fruit growth period of early maturing peach cultivars such as Empress, there is sufficient time for fruit growth to recover on Ethrel-treated trees so that fruit weight at harvest is not reduced.

(778) Lazcano, C. A., F. T. Davies, Jr., et al. (1999). Effect of auxin and wounding on adventitious root formation of prickly-pear cactus cladodes. HortTechnology 9(1): 99-102.
Mature cladodes of prickly pear cactus (Opuntia amyclaea, cv. Reina) were treated with 5 wounding methods and 4 concentrations of potassium salt indole-3-butyric acid (K-IBA) to stimulate adventitious root formation. The wounding method and K-IBA had highly significant effects on root number and root dry mass of cladodes. Interaction between K-IBA and wounding methods showed that greater root number was obtained at the higher auxin concentrations and with wounding methods that had

the greatest cut surface area. K-IBA concentrations from 4144 to 41thin442 µM (1000 to 10thin000 mg/litre) increased root dry mass. Only the wounding method affected rotting of cladodes. Treatments allowing suberization had a higher percentage of non-rotted cladodes. This research validates the commercial practice of allowing cladodes to suberize early in the propagation cycle. K-IBA altered rooting polarity and stimulated adventitious root formation along the wounded cladode surfaces. The vertical non-suberized wounding methods and auxin treatments were an excellent classroom demonstration for manipulating rooting polarity. It is suggested that auxin application and wounding could be of commercial benefit for enhanced rooting in the clonal regeneration of new selections for prickly pear cactus orchards.

(779) **Huang, N., K. A. Funnell, et al. (1999). Vernalization and growing degree-day requirements for flowering of Thalictrum delavayi 'Hewitt's Double'. HortScience 34(1): 59-61.**
Vernalization and growing degree-day (GDD) requirements of T. delavayi cv. Hewitt's Double were investigated by exposing crowns to cold storage for 0, 3, 6, 9, 12 or 15 weeks at 8°C, and subsequently planting them in a heated greenhouse under long-day conditions. Cumulative vernalization of crowns was complete after 6 weeks of cold storage at 8°C. The time to flower, including time at 8°C, was 3338 GDD (base temperature of 0°C) without vernalization and 2802 GDD after complete vernalization. Commercial recommendations for rapid and predictable flowering of T. delavayi cv. Hewitt's Double should include cold storage of crowns for a minimum of 6 weeks at 8°C as part of the 2802 GDD during vernalization and forcing.

(780) **Runkle, E. S., R. D. Heins, et al. (1999). Photoperiod and cold treatment regulate flowering of Rudbeckia fulgida 'Goldsturm'. HortScience 34(1): 55-58.**
To determine the flowering requirements of R. fulgida cv. Goldsturm, plants were grown under 9-h photoperiods until maturity, then forced at 20°C under one of 7 photoperiods following 0 or 15 weeks at 5°C. Photoperiods consisted of a 9-h day that was extended with incandescent lamps to 10, 12, 13, 14, 16 or 24 h; an additional treatment was a 9-h day with a 4-h night interruption (NI). Non-cooled plants remained vegetative under photoperiods _13 h, and essentially all plants flowered under photoperiods _14 h or with a 4-h NI. Flowering percentages for cooled plants were 6, 56 or _84 under 10-, 12- or _13-hour daylengths, respectively, and _84 for the NI treatment. Critical photoperiods were _14 or 13 h for non-cooled or cooled plants, respectively, and base photoperiods shifted from 13-14 h before cold treatment to 10-12 h following cold treatment. Within cold treatments, plants under photoperiods _14 hours or NI reached visible inflorescence and flowered at the same time and developed the same number of inflorescences. Fifteen weeks of cold hastened flowering by 25-30 days and reduced nodes developed before the first inflorescence by 28-37%. Cold treatment provided little or no improvement in other measured characteristics, such as flowering percentage and uniformity, flower number, plant height and vigour.

(781) **Rose, M. A. and B. Biernacka (1999). Seasonal patterns of nutrient and dry weight accumulation in Freeman maple. HortScience 34(1): 91-95.**
Seasonal patterns of N, P and K accumulation and remobilization in Acer freemanii cv. Jeffersred were studied to guide future improvements in fertilization efficiency. Leaves, stems and roots of container-grown trees were harvested over a 12-month period (June to June) in each of 2 experiments in Columbus, Ohio. Plants were fertilized from June to October with 3 rates of soluble fertilizer (50, 100 and 200 mg N/litre). Fertilizer rate had linear and quadratic effects on dry weight and nutrient contents, but did not affect seasonal accumulation patterns. Whole-plant nutrient contents and dry weights increased until mid-October, prior to leaf abscission. The largest fractions of nutrients and dry weight were allocated to leaves until early September. Between September and October, the most rapid accumulation of N, P and dry weight occurred in root tissue. Highest nitrogen recovery efficiency occurred in late summer (experiment 2) or early autumn (experiment 1). There was no statistically significant evidence for N, P or K resorption in autumn, but evidence of N (but not P or K) remobilization in the spring was very strong. Whole plant dry weight doubled between April and June, while _50% of the N stored in woody tissues was translocated to new shoots.

(782) **Klock Moore, K. A. and T. K. Broschat (1999). Differences in bedding plant growth and nitrate loss with a controlled-release fertilizer and two irrigation systems. HortTechnology 9(2): 206-209.**
In a greenhouse experiment conducted in March 1997, growth of hand-watered and subirrigated cv. Ultra Red petunia (Petunia X hybrida) and cv. Super Elfin Violet impatiens (Impatiens walleriana) plants, in 400-ml pots filled with peat, vermiculite and perlite (60, 25 and 15%, respectively), were compared when grown using 4 controlled-release fertilizer rates and 4 fertilizer placements. Furthermore, the amount of NO3-N leached from hand-watered plants was compared with the amount captured by the subirrigation system. Before planting, Osmocote (14N-6.2P-11.6K; 4-month release) was either top-dressed (TD), layered in the middle of the pot (M), layered at the bottom of the pot (B), or incorporated throughout (I) the substrate at 1.25, 2.5, 5.0 or 7.5 kg/m3. Shoot dry mass of petunia plants was similar between both irrigation systems and among the 4 fertilizer placements. Subirrigated petunias fertilized with 2.5 kg/m3 had similar shoot dry mass to hand-watered petunias fertilized with 7.5 kg/m3. Hand-watered impatiens had greater shoot dry mass than subirrigated impatiens. Hand-watered impatiens also had greater shoot dry mass in pots with fertilizer at TD, M, or I than with fertilizer at B, but no difference in growth was observed in subirrigated impatiens among the different fertilizer placements. Finally, significantly more NO3-N was leached from hand-watered plants than was captured with the subirrigation systems.

(783) **Cole, J. C. (1999). Propazine has little effect on growth of several containerized woody plant species. HortTechnology 9(2): 198-202.**
Woody plant species growing in 1-gal (3.8-litre) containers were treated in 1995 and 1996 with the herbicide propazine at 0, 1, 2, or 4 lb/acre (0, 1.1, 2.3, or 4.5 kg/ha). Species studied in 1995 included rose-of-sharon (Hibiscus syriacus cv. Double Purple), Japanese boxwood (Buxus microphylla cv. Green Mountain), butterfly bush (Buddleia davidii var. veitchiana cv. Nanho Purple), euonymus (Euonymus fortunei var. acutis cv. Emerald 'n Gold), forsythia (Forsythia X intermedia cv. Lynnwood Gold), fire thorn (Pyracantha angustifolia cv. Gnome), and Japanese spiraea (Spiraea japonica cv. Goldflame). Crape myrtle (Lagerstroemia indica cultivars Acoma and Zuni) and juniper (Juniperus chinensis cv. Pfitzeriana) were added, and euonymus and Japanese spiraea were omitted, in 1996. In both years, statistical analyses revealed differences in height and visual quality between plants exposed to propazine and control plants of some species; however, differences were inconsistent in that some plants treated with propazine were larger or rated better than control plants while other plants were smaller or of lower quality than their corresponding control plants. In all cases, differences among propazine treatments within each species were <1.2 inches (3 cm) in height while decreases in visual quality compared with control plants were most evident in plants receiving four times the recommended rate of propazine. The horticultural significance of these differences was, therefore, considered small, suggesting that all of the species tested are

tolerant to propazine applied at the recommended rate of 1 lb/acre.

(784) Davidson, C. G. (1999). 'Morden Snowbeauty' rose. HortScience 34(2): 366-367.
Morden Snowbeauty is a new, disease resistant, semi-double, white-flowered Parkland introduction which will survive zone 2 winters with only minor injury. It has a complex pedigree: Morden Amorette/Prairie Princess crossed with Mount Shasta//Rosa arkansana/Adelaide Hoodless. Plants of Morden Snowbeauty are relatively open, have semi-erect upright canes and have a mean height of 74 cm and width of 98 cm. Inflorescences contain 3-10 flowers (mean 5). Semi-double flowers are 6-12 cm in diameter (mean 8 cm) and appear almost flat. Flower buds (157A) are acutely pointed. Flowers have a weak fragrance. Petals are 2.2-3.3 cm long and 1.8-3.6 cm in width and are smooth, orbicular with rounded tips and reflexed outer edges. Flower coverage compares well with other Parkland roses. Trials indicated excellent resistance to local populations of blackspot (Diplocarpon rosae), powdery mildew (Sphaerotheca pannosa) and rust (Phragmidium).

(785) Zhang, M., M. Nyborg, et al. (1998). Comparison of controlled-release nitrogen fertilizers on turfgrass in a moderate temperature area. HortScience 33(7): 1203-1206.
Coating of conventional urea with polymers is designed to improve N availability to crops. A field experiment was conducted from 1993 to 1994 on turfgrass at Ellerslie, Alta., Canada, to determine release rates of coated urea applied on turfgrass thatch surface, and the effect of coated urea application on growth, color, and N uptake of turfgrass. The experiment was established on existing stands of a mixture of 'Merion' Kentucky bluegrass (Poa pratensis L.) and 'Gennuina' creeping red fescue (Festuca rubra L.) growing on a Black Chernozemic (Typic Cryoboroll) soil. The annual rate of N application was 100 kg(.)ha-1 in 1993 and 1994. The release rate of urea fertilizers was determined by the weight loss of the fertilizer granules after application in polyvinyl chloride (PVC) cylinders inserted into the turfgrass thatch. Some coated urea fertilizers released most of their N within the growing season (e.g., Sherritt-G, Polyon 4%, and SulfurKote), while others released only half their N (e.g., Esso T-90 and Meister 7), probably because of the cool ambient summer temperature in the area. The growth and color of turfgrass were more uniform in some controlled-release fertilizer treatments (e.g., Esso T-90, Meister 7, Polyon 4%, and SulfurKote) than in noncoated urea and NH4NO3 treatments. Promotion of growth in 1994 as a residual effect of the 1993 controlled-release urea fertilizer application was also noted. The results suggest that the application of some controlled-release urea fertilizers (with 70- to 90-day release rates) can produce the most consistent quality turfgrass.

(786) Bolar, J. P., J. L. Norelli, et al. (1998). An efficient method for rooting and acclimation of micropropagated apple cultivars. HortScience 33(7): 1251-1252.
To root tissue-cultured apple cultivars, shoots from proliferating cultures were first transferred to root induction medium with IBA for 1 week in the dark. Shoots were later transferred to the same medium without IBA and incubated under light for elongation of the roots. Rooted shoots were then transferred to Jiffy-7s supplemented with biological plant protectant and fertilizer, and incubated in plastic humidity trays. After 2 to 3 weeks, plants were transferred to pots and covered with plastic bags to facilitate acclimation. This technique has resulted in 70% to 100% of shoots selected in vitro producing vigorously growing, healthy plants in the greenhouse.

(787) Sibley, J. L., J. M. Ruter, et al. (1999). Bark anthocyanin levels differ with location in cultivars of red maple. HortScience 34(1): 137-139.
The objective of this study was to determine differences in the bulk anthocyanin content of bark tissue of container-grown Acer rubrum and Acer Xfreemanii at 2 Georgia (USA) locations with different environmental conditions. Rooted cuttings and tissue-cultured plantlets of 8 cultivars were grown in either Blairsville or Tifton, Georgia (USDA Hardiness Zones 6b and 8a; American Horticultural Society (AHS) Heat Zones 5 and 8, respectively), from June 1995 until December 1996. Bark tissue from twigs of trees grown in Blairsville was visually redder and contained more total anthocyanin than did that of trees grown in Tifton. Levels of total anthocyanins were higher at Blairsville (0.087 mg/g) than at Tifton (0.068 mg/g). At both locations the levels were highest in cv. Landsburg (syn. Firedance), followed by Franksred (syn. Red Sunset) and October Glory. This is the first report to quantify anthocyanin differences in bark tissue of container-grown trees. Cooler nights in Blairsville might have contributed to increased coloration by reducing respiratory losses, thus leaving more carbohydrates available for pigment production.

(788) Raese, J. T. (1997). Cold tolerance, yield, and fruit quality of 'd'Anjou' pears influenced by nitrogen fertilizer rates and time of application. Journal of Plant Nutrition 20(7/8): 1007-1025.
Low and moderate rates of ammonium nitrate (NH4NO3) fertilizer were applied in late winter or late summer to mature 'd'Anjou' pear (Pyrus communis, L.) trees (planted 1963, 1965) from 1976 to 1994. Data on cold tolerance, nutrition, yield and fruit quality in relation to nitrogen (N) fertilization were collected between 1980 and 1988. Early autumn cold tolerance was higher for trees receiving low N rates versus moderate N rates in either late winter or late summer. In late autumn and early winter, cold tolerance increased for all trees, and little difference in winter hardiness existed for any N treatment. By mid-winter, cold tolerance was higher for trees receiving the moderate rate of N in late winter versus low N in late summer. Cold tolerance was relatively high throughout autumn and winter freeze-test periods for trees fertilized with low N in late winter. Tree vigor, fruit size, leaf N, and fruit N were highest for trees receiving the late winter, moderate rate of N. Yield was lowest, but fruit firmness, fruit quality and fruit calcium (Ca) concentrations were highest for trees treated with the late winter, low rate of N. The incidence of cork spot was lower from trees with the late winter, low N treatment than for the late summer, moderate N-treated trees.

(789) Devlin, R. M., J. Karczmarczyk, et al. (1982). Stimulation of plant growth by low concentration of napropamide Zea mays, maize, Triticum vulgare, wheat, Raphanus sativus, radishes, Glycine max, soybeans, preemergence herbicides as plant growth regulators. Plant Grow Regul 1(2): 113-117.
This study demonstrates that the pre.emergence herbicide napropamide will enhance plant growth when applied at very low concentrations. Stimulation of shoot elongation, fresh weight, and dry weight was observed when seeds of wheat, corn, raddish, and soybean were soaked In very dilute solutions of napropasnide for 6 hr. Bloinass synthesis by Red Kidney bean was dramatically Increased by 10 µm napropa-mide, a 24.3% increase in fresh weight and a 76% increase in dry weight being observed. It is apparent that napropamide should be listed with those herbicides that have ex-hibited growth regulator properties.

(790) Whitwell, T. and K. Kalmowitz (1989). Control of prostrate spurge (Euphorbia humistrata) and large crabgrass (Digitaria sanquinalas) in container grown Ilex crenata 'Compacta' with herbicide combinations. Journal of Environmental Horticulture 7(1): 35 - 37.
Granular herbicide combinations were evaluated for longevity of prostrate spurge (Euphorbia humistrata Engelm.ex.Gray) and

large crabgrass (Digitaria sanguinalis L.) control. Rout (oxyfluorfen + oryzalin), Ornamental Herbicide 2 (oxyfluorfen + pendimethalin), Ronstar plus Modown (oxadiazon + bifenox) and Ronstar (oxadiazon) were applied at labeled rates and twice labeled rate in container grown Compact Japanese Holly (Ilex crenata 'Compacta'). Weeds were reseeded each month but herbicides were not reapplied. The normal use rate controlled both weeds during the first 30 days after treatment (DAT) while twice this rate controlled the weed species at 60 DAT. No herbicide treatment effectively (>80%) controlled prostrate spurge 90 DAT. The high rate of Rout controlled (>80%) crabgrass at 90 DAT. Weed numbers and above ground biomass reflected visual control ratings. Compact Japanese Holly was not injured by any treatment.

(791) Ruizzo, M. A., E. M. Smith, et al. (1983). Evaluations of four herbicides in slow release formulations for container grown landscape crops. .
Technical grade formulations of alachlor, chloramben, naptalam and propachlor were individually incorporated into dicalcium phosphate and plaster of Paris slow release tablets and applied at 1 tablet/container delivering 20 and 40 kg a.i./ha. All controlled Poa annua, Portulaca oleracea, Polygonum pensylvanicum and Setaria lutescens [= S. pumila] with no significant injury to cotoneaster, euonymus, forsythia and privet cv.

(792) Hanninen, K. S. (1998). Effects of clovers as vegetative ground cover on the growth of red birch in nursery field production. J hortic sci biotech 73(3): 393-398.
During 1992-95, clover species were evaluated as vegetative ground covers in nursery field production of micropropagated red birch (Betula pubescens f. rubra) in Finland. The clover species and cultivars were Trifolium pratense cv. Bjursele, T. repens cv. Jogeva, T. repens cv. Sonja, T. hybridum cv. Frida, T. incarnatum cv. Opolska, T. resupinatum and T. subterraneum. One treatment was grass sod Festuca rubra cv. Ensylva, and the control was coverless ground kept weed free by hand hoeing. Stem diameter, stem height, leaf area and leaf size were all reduced in the perennial clover and grass plots. The annual clovers, T. incarnatum, T. resupinatum and T. subterraneum were noncompetitive with the trees. Because of its low growth habit, T. subterraneum appeared to be the most suitable of the tested clovers as a ground cover crop.

(793) Testezlaf, R., C. A. Larsen, et al. (1999). Tensiometric monitoring of container substrate moisture status. HortTechnology 9(1): 105-109.
The objective of these experiments was to evaluate the use of tensiometers to monitor substrate moisture tensions for Metro-Mix 500 and 2 pine bark: 1 Canadian peat: 1 sand (PBPS, by volume) used for container-grown azalea (Rhododendron indicum cv. Mrs. G.G. Gerbing) and chrysanthemum (Dendranthema grandiflora cv. Coral Charm). Commercially available ceramic cups of 2 sizes, small (0.95 cm diameter and 2.86 cm long, and large (2.22 cm diameter and 7.62 cm long) were used to construct pressure transducer-equipped tensiometers. Data from these greenhouse experiments indicate that either the small or large ceramic cup could be used to monitor substrate tensions at which water would be available to container-grown plants.

(794) Pacific-Resource-Consultants (1995). Environmental guidelines for the nursery and turf industry in British Columbia. Victoria, BC, Queen's Printer.

(795) Briggs, J. and T. Whitwell (1997). Minimizing the pesticide exodus. American Nurseryman(June 1): 58 - 60, 62, 64 - 67.
Research shows that several factors affect a pesticide's presence in runoff from container nurseries. Knowing these factors can help nusery professionals keep pesticides where they belong.

(796) Murphy, G. (199?). Minor use of pesticides. Canadian Florist, Greenhouse and Nursery: 32.

(797) Ahrens, J. (1994). Herbicides: Minimizing use and maximizing growth of field and container stock. Recycling and Resource Conservation. C. W. Heuser and P. E. Heuser. Harrisburg, PA, Pennsylvania Nurserymen's Association, Inc: 97 - 104.

(798) Calkins, J. B. and B. T. Swanson (1994). Comparison of oxadiazon (Ronstar) alone and in combination with other herbicides for chickweed (Stellaria media) control: 1993 & 1994. 1994 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 222 - 227.
Oxadiazon is an effective herbicide for weed control in nursery field and container production systems. Oxadiazon is maufactured and sold, under the trade name Chipco Ronstar, by the Rhone Poulenc Ag. Co. in granular (2G) and wettable powder (5OWP) formulations. Although oxadiazon provides control of a broad spectrum of weed species, oxadiazon does not control the several species of chickweed, mainly common chickweed [Stellaria media (L) Cyrillo.]. Since most other weeds are controlled, this escape weed often becomes established in pure stands and becomes quite vigorous in the absence of competition from other weeds. The inability of oxadiazon to control chickweed makes it an unacceptable herbicide option where this weed is present This research project compares oxadiazon alone and in combination with several other herbicides for chickweed control.

(799) Swanson, B. T. and J. B. Calkins (1995). Fall applied herbicides for nursery field stock: 1992 - 1998. 1995 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 27?.
Herbicides have proven to be valuable, cost effective and efficient weed control options in nursery field production systems. Although pre-emergent herbicides are most often applied In the early spring, previous herbicide research at the TRE Nursery has indicated that application of herbicides In the fall has several potential benefits over spring applications. Some benefits associated with fall herbicide application include: reduced herbicide injury for plants that are dormant in the fall, improved incorporation and activation by fall and winter precipitation without supplemental irrigation, herbicides are present and active in early spring when weeds initially become established and long before fields are accessible by application equipment, and herbicide applications are not required during the busy spring planting season when personnel and equipment are needed elsewhere. To expand the range of species evaluated and the number of herbicides recommended for fall application, this study was initiated in fall, 1992, and will continue through the 1998 growing season.

(800) Swanson, B. T. and J. B. Calkins (1994). Fall applied herbicides for nursery field stock: 1992 - 1998. 1994 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 141 - 154.
Herbicides have proven to be valuable, cost effective and efficient weed control options in nursery field production systems. Although preemergent herbicides are most often applied in the early spring, previous herbicide research at the TRE Nursery has indicated that application of herbicides in the fall has several potential benefits over spring applications. Some benefits associated with fall herbicide application include: reduced herbicide injury for plants that are dormant in the fall, improved incorporation and activation

by fall and winter precipitation without supplemental irrigation, herbicides are present and active in early spring when weeds initially become established and long before fields are accessible by application equipment, and herbicide applications are not required during the busy spring planting season when personnel and equipment are needed elsewhere. To expand the range of species evaluated and the number of recommended herbicides for fall application, this study was initiated in fall, 1992, and will continue through the 1998 growing season.

(801) Swanson, B. T., J. B. Calkins, et al. (1994). Immediate and long range effects of spring applied herbicides on new and established nursery tree fields: 1990 - 1996. 1994 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 155 - 172.
Herbicide management can be a safe, economical method of weed control in nursery field production systems. Herbicide efficacy and phytotoxicity data are critical for proper herbicide selection and management. Although it is certainly recommended that herbicides be rotated on a regular basis, information regarding the long-term effects of repeated herbicide applications over several years on plant growth and weed population dynamics is needed. In addition, data on herbicide residue accumulation, leaching potential and subsequent effects on cover crop establishment must also be considered. This research addresses the immediate and long-range effects of repeated herbicide applications on trees and shrubs, and on edaphic and environmental factors.

(802) Swanson, B. T. and J. B. Calkins (1995). Immediate and long range effects of spring applied herbicides on new and established nursery tree fields: 1990 - 1996. 1995 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 189 - 206.
Herbicide management can be a safe, economical method of weed control in nursery field production systems. Herbicide efficacy and phytotoxicity data are critical for proper herbicide selection and management. Although it is certainly recommended that herbicides be rotated on a regular basis, information regarding the long-term effects of repeated herbicide applications over several years on plant growth and weed population dynamics is needed. In addition, data on herbicide residue accumulation, teaching potential and subsequent effects on cover crop establishment must also be considered. This research addresses the immediate and long-range effects of repeated herbicide applications on trees and shrubs, and on edaphic and environmental factors.

(803) Calkins, J. B., B. T. Swanson, et al. (1994). Comparison of incorporated, topdressed and fertigate fertility and overhead, pusle and capillary mat irrgation for container nursery stock production - Plant performance, fertility release, nutrient runoff potential and environmenal impact considerations: 1994 - 1995. 1994 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 70 - 86.
Media fertility, plant nutrient availability, and subsequent plant nutrition are critical factors in the production of quality landscape plant materials. Fertility is an important growth factor that, unlike many others, can be modified by growers to promote plant growth and development. The current trend in container fertility management is the incorporation of slow release fertilizers into container media prior to containerization of plant material. Previous research by the UM TRE program (1987-1988) has clearly demonstrated the superiority of incorporated slow release fertilizers over topdressed fertilizer application methods in promoting vigorous plant growth and producing quality container grown plants. A common problem associated with incorporated fertilizers, however, is longevity. When plants are grown for more than a year prior to being sold or upgraded, fertility is often depleted and additional topdressed fertilizer must be provided. This requirement increases production costs. Controlled release fertilizers that provide appropriate plant nutrition over a two-year production cycle, under growing conditions in the upper midwest, would be a tremendous improvement over current fertility management strategies. Driven by competition and demand, fertilizer technology is changing rapidly and new developments may soon fulfil this requisite. Many new fertilizer products are appearing on the market annually, however, determining which fertilizer formulation is best suited to a particular species, production system, or geographical location, is a complex process. The tenet that any balanced fertilizer is suitable for all situations is no longer legitimate. TRE Nursery Program research continues to address these vital fertilizer management concerns through its ongoing fertility evaluation program. This study continues the search for and evaluation of new, innovative, controlled release fertility technology that will provide long term plant nutrition in container production systems.

(804) Ombrello, T. and G. Wulster (1999). Improving transplants. Greenhouse Insider(April): 4, 6.
Ethephon could play a key role in improving tomato transplant quality

(805) Johnson, B. (199?). The next step in irrigation: Subsurface drip. The Growing Edge: 52 - 56.

(806) Smith, S. W. (1998). The irrigation sensation. American Nurseryman 187(3): 58, 60, 62 - 63.
Increasing water costs are a headach to landscapers eith particularly large projects. New irrigation-system technology may reduce water costs.

(807) Heacox, L. (1997). Put automation in irrigation. American Vegetable Grower(May): 40 - 41.
With water levels decreasing in semi-aridregions of the U.S.- and fuel costs to pump the remaining water rising - careful irrigation management in agricu1ture is more im-portant than ever. That's where new ways of applying existing technology can help.

Several products have been recently released or are set for introduction in the next year. These irrigation aids can be used alone or com-bined to give grow-ers flexibility and affordability.

(808) Corkal, D., J. Sketchell, et al. (1996?). Rural prairie water quality: Searching for solution for on-farm users. Saskatoon, SK, Saskatchewan Research Council.
Federal and provincial agencies working on water quality in Saskatchewan have completed three years of research focused on finding new ways to improve rural Prairie water quality for farm use. The results are very positive with the potential to use both reservoir coagulation and biological treatment of domestic water at the individual farm level. This paper provides an overview of the research and some of the promising results that were achieved.

The goal of the research was to improve on-farm water quality, in terms of human and animal health, and aesthetics. The major surface water quality issues examined in this study included high levels of dissolved organic carbon IDOC), phosphates and turbidity indicators of conditions that could lead to human or animal health problems), and colour Ian indicator of the aesthetic quality of the water).

This research was based on several concepts:
- *people on farms have the right to good quality water for drinking, domestic use, livestock watering and on-farm uses;*
- *existing water supplies on many farms are often of very*

poor quality;

- *improving the quality of existing water supplies can be a viable alternative to finding new water supplies, an alternative that makes sense from both a technological and a financial perspective;*
- *water quality varies across the Prairies and with the water source. Therefore, water treatment technologies must be designed to treat specific problems with the appropriate combination of technologies;*
- *many conventional water treatment technologies are not effective or efficient for treating organic-rich surface water for long periods of time without maintenance;*
- *on-farm reservoirs or dugouts are easily studied, and the results can be applied to other water sources.*

Conventional means of water treatment for Prairie farms vary from the 'do nothing' approach to rapid sand filtration, granular activated carbon filtration and chlorine disinfection. Some households use membrane technology such as reverse osmosis units to improve small quantities of drinking water at the kitchen tap. Other processes such as distillation or ceramic filters are occasionally used. None of these approaches is particularly successful over the long-term in ensuring good enough water quality in sufficient volumes to meet all farm and household needs. Coagulation and biological treatment, when properly used, can be promising ways to improve on-farm water quality.

(809) Camp, C. R. (1998). Subsurface drip irrigation: a review. Trans ASAE 41(5): 1353-1367.
A comprehensive review of published information on subsurface drip irrigation was performed to determine the state of the art on the subject. Subsurface drip irrigation has been a part of drip irrigation development in the USA since its beginning about 1960, but interest has escalated since the early 1980s. Yield response for over 30 crops indicated that crop yield for subsurface drip was greater than or equal to that for other irrigation methods, including surface drip, and required less water in most cases. Lateral depths ranged from 0.02 to 0.70 m and lateral spacings ranged from 0.25 to 5.0 m. Several irrigation scheduling techniques, management strategies, crop water requirements, and water use efficiencies were discussed. Injection of nutrients, pesticides, and other chemicals to modify water and soil conditions is an important component of subsurface drip irrigation. Some mathematical models that simulate water movement in subsurface drip systems were included. Uniformity measurements and methods, a limited assessment of root intrusion into emitters, and estimates of overall system longevity were also discussed. Sufficient information exists to provide general guidance with regard to design, installation, and management of subsurface drip irrigation systems. A significant body of information is available to assist in determining relative advantages and disadvantages of this technology in comparison with other irrigation types. Subsurface drip provides a more efficient delivery system if water and nutrient applications are managed properly. Waste water application, especially for turf and landscape plants, offers great potential. Profitability and economic.

(810) Mathers, H. (1999). The shoot-to-root bond. American Nurseryman(May 15): 66 - 68, 70.
Understanding the complex and iterrelated physiological and environmental processes invloved in hardening woody plants can help growers improve these plants' cold tolerancy

(811) Flint, H. L. (1999). Globe trotters. American Nurseryman(April 1): 68 - 70, 72, 74, 76 - 83.
Coming from faraway lands, exotic viburnums are beautiful, useful and provide year-round interest in American landscapes

(812) Scwartz, T. (1999). Sorbus decora. American Nurseryman(April 1): 126.
Plant description of Sorbus decora (showy mountain ash)

(813) Calkins, J. B. and B. T. Swanson (1998). Cold acclimation, hardiness and winter injury of field-grown plants. American Nurseryman(September 15): 56 - 59.
For field-grown woody plants, the onset of winter can mean injury or death. While winter damage to stems is a problem, root injury is more detrimen-tal. Thus, protecting the root system from low temperatures is crucial for plant health and survival.

The most common field-management practice involves growing plants in bare soil and controlling weeds by cultivation or herbicides. Yet, this method can leave roots vulnerable to extreme soil temper-atures. A less traditional method is to in-terplant crops as groundcovers in the same area as nursery stock. Cover crops may insulate the ground and promote deeper root systems, thus decreasing winter injury.

(814) Flanagan, P. C. and W. T. Witte (1991). Effects of chemical root pruning on root regeneration and cuellular structure of viburnum root tips. Proceedings from the Southern Nurserymen's Association Research Conference 36: 46 - 49.
Increased secondary root growth was observed in viburnum plant., due to chemical root pruning with copper hydroxide in latex paint applied to inner container surfaces. Root systems with more secondary branching, thus more root tips, should provide a larger root surface area for absorption of water and minerals, and should respond well when set in the landscape.

(815) Adalsteinsson, S., M. Gussarsson, et al. (1997). Monitoring copper-induced changes in fine root geometry of birch (Betula pendula) using nutrient film technique (NFT). Physiologia Plantarum 99(3): 379-384.
Birch (Betula pendula) seedlings were grown in a nutrient film technique (NFT) system and exposed to additional 0-5 μM Cu for a period of 8 days. The NFT system permitted undisturbed growth of the roots during monitoring. Cu experiments were carried out in a split-root setup both with a uniform and differentiated Cu supply to investigate growth responses of roots grown in a homogeneous and heterogeneous root environment, respectively. At uniform external Cu supply, average root length was affected by increased Cu concentration during the first four days, while during the next four days only the overall root length (product of root length and root number) was significantly reduced. During the first four days in the split-root experiments with differentiated Cu supply, additional Cu primarily reduced root number on the Cu-treated parts of the root system but at higher Cu concentrations the overall root length was also significantly reduced. In contrast, number of roots and average root length in the part of the root system not exposed to Cu increased when 1, 2 and 5 μM Cu was added to the other side. Growth parameters were affected differently at the beginning of the heavy metal exposure compared with later stages of exposure, which may indicate acclimatization to Cu stress.

(816) Aldrich, J. H., J. G. Norcini, et al. (1996). Effect of cupric hydroxide-treated containers on Bougainvillea propagation and growth after transplanting. Journal of Environmental Horticulture 14(4): 181-183.
Cupric hydroxide (100 g/litre) in a latex paint was sprayed on the interior of propagation cups to evaluate the effects on rooting of Bougainvillea glabra cv. Sanderiana cuttings and their growth after transplanting. Forty-two-day-old rooted cuttings propagated in cupric hydroxide-treated cups had a compact rootball with no root circling and tended to have more primary roots. From 91 to

144 days after transplanting 42-day-old rooted cuttings into non-treated 3.8-litre containers, transplants from the cupric hydroxide-treated cups had a greater growth index, principally due to increased height, than transplants from non-treated cups. However, the cupric hydroxide treatment did not significantly affect shoot or root fresh and dry weights 144 days after transplanting.

(817) Haeseler, C. W. and D. H. Petersen (1974). Effect of cupric hydroxide vineyard sprays on Concord grape yields and juice quality. [Uncinula necator]. Plant Disease Reporter 58(6): 486 - 489.
Sprays containing 83% cupric hydroxide adversely affected cluster and berry weights of Concord grapes, resulting in reduced yields. Juice quality, flavour and colour were also adversely affected. In addition, shoot growth was retarded and defoliation was induced. Yields were reduced and juice quality, flavour and colour adversely affected by sprays (used to control Uncinula necator) containing 83% cupric hydroxide. In addition shoot growth was retarded and defoliation induced.

(818) Stinson, R. F. (1956). Algal growth and the performance of flowering plants in clay pots treated with copper naphthenate. Journal of the American Society for Horticultural Science 64: 564 - 568.

(819) Stinson, R. F. and C. G. Keyes (1953). Preliminary report on copper and zinc napthenate teratments to control algae growth on clay flower pots. Journal of the American Society for Horticultural Science 61: 569 - 572.

(820) Leatherman, M. (1939). The use of copper resinate as a treatment for paper pots. Journal of the American Society for Horticultural Science 37: 951 - 955.

(821) Hare, J. D., P. A. Logan, et al. (1983). Suppression of Colorado potato beetle, Leptinotarsa decemlineata (Say), (Coleoptera:Chrysomelidae) populations with antifeedant fungicides. Environ Entomol 12(5): 1470-1477.
Laboratory, small-field plot and commercial-scale experiments were carried out in the USA to determine whether antifeedant fungicides might reduce the suitability of potato crops for Leptinotarsa decemlineata (Say) while simultaneously protecting potato from early and late blight. In the laboratory, fungicides formulated from fentin hydroxide and cupric hydroxide reduced feeding by 95 and 61%, respectively. In small-field plots in Connecticut, larval densities were significantly reduced where either of these compounds was used regularly. In commercial-scale experiments in Connecticut, populations were significantly reduced and required fewer insecticide applications for acceptable control where fentin hydroxide was used regularly.

(822) Pitcher, R. S. and D. G. McNamara (1972). The toxicity of low concentrations of silver and cupric ions to three species of plant-parasitic nematodes. Nematologica 18(3): 385 - 390.
In vitro tests with concentrations of 0.1 and 0.01 ppm Ag+ ions and 10.0, 1.0 and 0.1 ppm Cu++ ions on 3 species of nematode showed Pratylenchus penetrans to be the most susceptible to silver, and Xiphinema diversicaudatum the most susceptible to copper. Aphelenchoides ritzemabosi was the least affected by either metal. These results illustrate the potential dangers to living nematodes of water from metal-condenser stills and of the use of phosphor-bronze sieves in the final stages of extraction processes. The results of a pot-trial suggested that silver salts are of little value in the control of A. ritzemabosi in the field.

(823) Hare, M. D. (1993). Effects of frost and frost protectants on tall fescue seed production. New Zealand Journal of Agricultural Research 36(4): 399-405.
A study of the effects of frost on Festuca arundinacea cv. Grasslands Roa showed that reproductive tillers were particularly sensitive to frost damage at spike emergence and during anthesis. Two air frosts (-2 and -5°C) were applied to reproductive tillers for one 6-h cycle at either spike emergence, anthesis, or 4, 6, or 8 d after anthesis. The -5°C frost destroyed all seed heads. A single exposure to -2°C frost reduced seed yield by nearly 50% but had relatively less effect on seed weight and germination, provided frost did not occur at spike emergence or anthesis. Developing seed 6- and 8-d-old was less susceptible to -2°C frost, despite some decrease in seed yield and a slight reduction in the rate of germination. Two frost protectants used in the study, an ethylene oxide condensate (Teric) and a cupric hydroxide (Kocide 101), did not prevent frost damage from occurring, but seed yield reduction after the -2°C frost was less in seed heads protected by Kocide 101 and Teric than in untreated seed heads.

(824) Doster, M. A. and R. M. Bostock (1988). Chemical protection of almond pruning wounds from infection by Phytophthora syringae. Plant Dis 72(6): 492-494.
Application of fosetyl-Al (as Aliette 80WP) (3 and 30 g a.i./litre) to almond pruning wounds prevented the formation of cankers caused by P. syringae and was effective during the time that nontreated wounds were susceptible to infection. Application of cupric hydroxide (as Kocide 101 77WP) (1.8, 18.3 and 740 g a.i./litre) to pruning wounds before inoculation with P. syringae resulted in the formation of fewer cankers than in nontreated wounds for most trials, but wounds treated with cupric hydroxide frequently showed at least 1 of the following signs of phytotoxicity; formation of clear gum, xylem discoloration, excessive inner bark dieback and abnormal wound-induced lignification.

(825) Viennot Bourgin, G. (1985). Birth of the Bordeax mixture. La naissance de la bouillie bordelaise. Phytoma(371): 22-23.

(826) Brothers, C. T. and R. M. Lapierre A model of the mechanism of root control in copper treated nursery containers, Premium Compounded Products, LLC. 1998.

(827) Prell Swaid, A. and G. Schwedt (1994). A screening procedure for heavy metals in soil extracts by alcohol dehydrogenase and urease inhibition. Acta Hydrochimica et Hydrobiologica 22(2): 70-75.
A screening method for heavy metals in aqueous extracts of soil is presented which is based on inhibition of the enzymes urease and alcohol dehydrogenase. The method is suitable to detect cupric and mercury ions in concentrations below 0.01 mg/L and several other heavy metal ions in 1000 fold higher concentration. It is shown that the test may be used for screening of mercury ion concentrations exceeding 0.03 mg/L in aqueous solution when copper chelators are added to the test system. The usefulness of the presented tests to detect heavy metals eluted from soil was verified with samples from ore mining waste. The concentration of copper, lead, and zinc eluted from these samples to different amount was determined by atomic absorption spectrometry and was in good agreement with the enzyme inhibition data obtained with these samples.

(828) Lima, J. S. (1994). Copper balances in cocoa agrarian ecosystems: effects of differential use of cupric fungicides. Agric ecosyst environ 48(1): 19-25.
This paper presents a synthesis of an investigation on the fate of copper following the use of cupric fungicides in cocoa ecosystems in Bahia/Brazil. For the investigation three plantations were determined: Site A without fungicide applications, Site B under

treatment for 5 years and Site C for 16 years. As input-output balances reveal the imbalance of processes and the existence (or non-existence) of a steady state of the ecosystem an attempt is made here to establish a balance of Cu cycling in the three cocoa plantations. The results so far obtained indicate that an input-output balance can be an appropriate means to reveal the accumulation of Cu within the ecosystem, as an anthropogenic agent.

(829) Hino, K., C. d. Kreij, et al. (1995). Absorption of various types of chelated copper in a low concentration range by cucumber. Journal of Plant Nutrition 18(5): 1049-1056.
Two experiments were conducted to compare absorption of copper (Cu) from cupric chloride (CuCl2) and various types of chelated Cu in a low concentration range by cucumbers. In the first experiment, two varieties of cucumber were grown on rockwool for 40 days in a glasshouse with standard nutrient solution which contained six different concentrations of CuCl2 (0, 0.05, 0.10, 0.20, 0.40, and 0.80 micromoles/L). Copper deficiency symptoms were examined during the growing period, and the total nitrogen (N), iron (Fe), manganese (Mn), zinc (Zn), and copper contents of young fully grown leaves were measured. There were no differences among treatments in the leaf contents of N and Mn. Copper contents increased and Zn decreased with increasing Cu levels. The content of Cu at the three low Cu treatments (including no Cu addition) were in the deficient range (48-65 micromoles/kg dry matter). The zero Cu level had paler green leaves than other treatments. No differences were apparent between varieties. The second experiment was carried out under exactly the same conditions as the first, but on the basis of the results of the first experiment, Cu treatments were 0, Cu-EDDHA at 0.4, Cu-DTPA at 0.4, Cu-EDTA at 0.4, Cu-NTA at 0.4, CuCl2 at 0.4 micromoles/L as Cu2+. After the experiment, the total N, Fe, Mn, Zn, and Cu contents of young, fully grown leaves were measured. There were no differences between treatments in the leaf contents of Cu except zero Cu level. They were in the range of 101-119 micromoles/kg dry matter. At no Cu addition treatment, the Cu content was only 31 micromoles/kg dry matter which is considered to be the deficiency level. For the other examined elements.

(830) Wegrzynowicz, E. and M. Saniewski (1992). Stimulatory effect of cupric ion on ethylene production in tulips. Acta Horticulturae 1(325): 291-296.
After 12 weeks of dry cooling at 5°C, tulip cv. Gudoshnik bulbs were grown in the greenhouse under natural light conditions. CuCl2 at 1.0 mM, applied to the inside of the flower buds when stems were 7-8 cm long, stimulated ethylene production in the pistil and the 4th (upper) internode, induced flower bud blasting and gum formation in the 4th internode and almost totally inhibited stem growth. At the same concentration, CuCl2 also stimulated in vitro ethylene production in pistils excised at different stages of shoot growth.

(831) Plastics, B. Technical Issue: The facts on copper pruning: 3.

(832) Smith, P. A. (1995). Bordeaux Mix, KSBW, channel 8: 2.

(833) Illinois, U. o. (1993). Bordeaux mixture. 1998.

(834) Whitelaw, M. (1996). What about copper fungicides? 1998.

(835) Walker, J. C. (1969). Discovery of Bordeaux mixture. Plant Pathology. Bombay, TATA McGraw-Hill: 751 - 752.

(836) Alexopoulos, C. J. (1962). family Peronosporaceae. Introductory Mycology. New York, John Wiley & Sons, Inc.: 162 - 163.

(837) Gouin, F. R. (1984). Updating landscape specifications. Journal of Environmental Horticulture 2(3): 98-101.
Changes in nursery growing practices, combined with an increasing number of untrained people entering the landscape contracting industry, has necessitated the development of landscape specification guidelines so detailed that individuals with minimal horticultural skills should be able to complete a landscape project successfully. Emphasis in guidelines must be placed on shallow planting, the cutting of outside roots of container grown plants to minimize root girdling and to encourage rapid establishment, soil pH requirements of plants, soil drainage specifications in relation to planters and in special land-scape situations, mulching materials and problems associated with over-mulching, stem girdling by ties and marking tapes, emphasis on root hardiness especially in relation to raised outdoor planters, learning to recognize properly dug large plants and the importance of plant nutrition.

(838) Appleton, B. L. (1993). Nursery production alternatives for reduction or elimination of circling tree roots. Journal of Arboriculture 19(6): 383 - 388.
A review of the literature, with special reference to ornamental woody plant stock. Tree roots that circle during nursery production have the potential, once planted in the landscape, to enlarge and become girdling roots that may stress or kill trees. Several nursery production alternatives have been developed to address this problem, including in-ground fabric, rigid plastic and 'pot-in-pot' containers, and above-ground modified rigid plastic, 'low-profile', 'soil sock' and copper-treated containers. Coating the interior wall of rigid containers (above- and in-ground) with a root growth-regulating copper compound (e.g. cupric hydroxide) appears to be the most effective and economically justifiable alternative.

(839) Barnett, J. P. and J. M. McGilvray (1974). Copper screen controls root growth and increases survival of containerized Southern Pine seedlings. Tree Planters' Notes 25(2): 11-12.
In Louisiana, seedlings of Pinus taeda and P. palustris raised in tubes on a copper screen [cf. FA 34, 3961] survived better after planting out (86-88%) than those raised without a copper screen (63-82%). Total root production was similar in the treatments. The superior results with the copper screen are attributed to its preventing the emergence of roots from the bottom of the tube before planting out.

(840) Saul, G. H. (1968). Copper safely controls roots of tubed seedlings. Tree Planters' Notes 19(1): 7 - 9.

(841) Arnold, M. A. and E. Young (1991). CuCO3-painted containers and root pruning affect apple and green ash root growth and cytokinin levels. HortScience 26(3): 242-244.
CuCO3 at 100 g.liter-1 in a paint carrier applied to interior container surfaces effectively prevented root deformation in container-grown Malus domestica Borkh. and Fraxinus pennsylvanica Marsh. seedlings. CuCO3 treatments nearly doubled the number of white unsuberized root tips in both species. CuCO3 treatment increased some measures of root and shoot growth before and after transplanting to larger untreated containers. Root pruning at transplanting tended to reduce root and shoot fresh and dry matter accumulation in F. pennsylvanica seedlings and shoot extension in M. domestica seedlings. In some cases, root pruning of M. domestica at transplanting from CuCO3-treated containers increased root growth compared to unpruned CuCO3-treated and untreated seedlings. Changes in growth induced by CuCO3 and root pruning were not related to changes

in trans-zeatin riboside-like activity in the xylem sap of apple.

(842) Burdett, A. N., D. G. Simpson, et al. (1983). Root development and plantation establishment success. Plant and Soil 71: 103-110.
Summary Batches of 2 + 0, bare-root lodgepole pine (Pinus ~on wria Dougl.) and white spruce (Picea glauca (Moench) Voss) seedings differing in provenance~ lifting date, or nursery of origin varied greatly both in root growth capacity (ROC) as measured by a laboratory assay and in early survivaland growth after field planting. Most of the variation in field performance was accounted for by the variation in RGC.

The lateral roots of lodgepole pine seedlings were pruned chemically by raising them in containers coated on the inside with cupric carbonate in latex paint. When field planted. the chemically root-pruned stock grew appreciably faster than control stock raised in unpainted containers. The difference in growth rate was associated with a difference in root form 4 years after planting.

Alternate Abstract: Bare-root planting stock of 2+0 white spruce and lodgepole pine, each of 4 provenances (from different nurseries) in batches lifted at 5-7 different dates, were tested for root growth capacity (RGC) [see FA 42, 53] before planting on a spruce and a pine forest site (respectively) in British Columbia. Most of the very wide variation in 1st-yr survival and growth was directly related to the RGC. In another trial, 3 provenances of lodgepole pine were sown in containers coated inside with cupric carbonate [see FA 40, 4240, etc.] and planted out at 1 yr old. At 4 yr after planting, the chemically root-pruned stock had much better developed lateral roots and 15% greater c.a.i. in ht. than stock raised in untreated containers.

(843) Dunn, G. M., J. R. Huth, et al. (1997). Coating nursery containers with copper carbonate improves root morphology of five native Australian tree species used in agroforestry systems. Agroforestry Systems 37(2): 143-155.
Seedlings of Acacia holosericea, Casuarina cunninghamiana, Eucalyptus argophloia, E. camaldulensis and Melaleuca bracteata, were raised in nursery containers which were coated with CuCO3 (50 g/litre, in a water-based paint solution) or left uncoated for 3 months. Seedling growth of all species was generally less in treated containers, although differences were relatively small. More importantly, CuCO3 treatment reduced the occurrence of lateral roots growing down or coiling around container walls for both three- and six-month-old seedlings. Twenty-four months after planting seedlings of both ages on a semiarid site in subtropical southeast Queensland, there was no effect of CuCO3 treatment on height or basal diameter development of seedlings. However, sample excavations of root systems showed that the poor root morphology exhibited by untreated seedlings when in the nursery had persisted in the field. As such, poor root form has the potential to reduce tree growth and wind firmness in the longer term, so these results suggest that chemical root-pruning is a helpful nursery practice when raising seedlings for dryland afforestation, and in circumstances where it may be necessary to retain seedlings in the nursery for longer than normal to take advantage of infrequent rainfall events.

(844) Gilman, E. F. and R. J. Beeson (1995). Copper hydroxide affects root distribution of Ilex cassine in plastic containers. HortTechnology 5(1): 48-49.
The root:shoot ratio of I. cassine plants grown 7 months in black plastic containers coated on the inside with copper hydroxide was less than that of plants in untreated containers. DW of roots <5 mm in diameter was significantly less in copper-treated containers than in untreated containers in the outer 1 cm of the rootball but not significantly different within the rootball. DW of coarse roots (>5 mm in diameter) within the rootball was not affected by copper hydroxide treatment either, but the treatment eliminated coarse roots in the outer 1 cm of the rootball.

(845) Ruter, J. M. (1996). Growth and flowering of three garden chrysanthemum cultivars produced in plastic or copper-impregnated fiber containers. Journal of Environmental Horticulture 14(4): 191-193.
A study was conducted with garden chrysanthemum cultivars Grenadine, Nicole and Tolima to evaluate growth and flowering in 3.6-litre fibre containers impregnated with cupric hydroxide compared with in 2.6-litre black plastic containers (controls). For all three cultivars, growth indices, shoot and root dry weights, and total biomass were greater in plants grown in fibre containers. Total number of flower buds per plant was 30, 32 and 53% higher in Grenadine, Nicole and Tolima, respectively, in fibre containers. Plants grown in cupric hydroxide-impregnated fibre containers had less root coverage at the container/substrate interface and no observable root circling in contrast to visible root circling in plants grown in black plastic containers. Foliar nutrient analysis on the cultivar Grenadine showed that K decreased and Fe and Cu increased when grown in cupric hydroxide-impregnated fibre containers. No visible nutrient abnormalities were observed.

(846) Blum, U. and G. Schwedt (1998). Urease inhibition test for effect-related investigations of copper speciation in water and soil extracts. Acta Hydrochimica et Hydrobiologica 26(4): 235-239.
In 80 different water samples, the inhibition effect of cupric ions was measured by application of a simple urease inhibition test. In relation to the total copper concentration, the inhibition permits an effect-related classification of drinking water, rain water, spring water, surface water, leakage water, waste water, and soil extracts. Drinking water contains high parts of cupric ions in the free hydrated form. Their copper content results in high urease inhibition and is caused by using copper pipes in house plumbing. In leakage water, waste water, and soil extracts, cupric ions are mainly complexed by organic compounds in the sample matrix. Hence, the inhibition effects are low. In soil extracts, the urease inhibition increased after an UV-decomposition procedure, but a decreasing effect was observed for a surface and a drinking water sample, respectively. The chemical oxygen demand and UV-absorbance at 255 nm measured before and after the procedure were correlated to the content of organic compounds, i.e., humic acid. In most samples, the organic matrix was not decomposed completely. The oxidizing decomposition apparently forms further complexing agents, which suppress the inhibition effect of cupric ions. In the rain water samples investigated, the content of organic compounds depended on rain intensity. The chemical oxygen demand and UV-absorbance, respectively, were low for rain water collected during strong rain periods and increased with decreasing rain intensity. The rain water trickled over sheet-lead roof showed an increase of urease inhibition compared with the simultaneously collected rain. Consequently, a decomposition of organic matrix could be demonstrated in rain water by use of the urease inhibition test.

(847) Goodman, B. A. and D. J. Lineham (1979). An electron paramagnetic resonance study of the uptake of copper (II) by wheat roots. Proceedings of the second New Zealand seminar on trace elements and health. J. Aggett, T. Kjellstrom and D. Crowe. Auckland, NZ, Trace Element Group, Department of Community Health, Auckland University.: 63 - 70.
Electron paramagnetic resonance (EPR) spectroscopy and its application to the uptake of cupric ions by wheat roots is described. An initial immobilization of Cu2+ on the root surface was followed by formation of a soluble complex having EPR

parameters indicative of Cu-amino acid complexes which formed initially in the intercellular spaces. The soluble amino acid content of the roots was determined using a computer model to calculate the possible distribution of Cu2+ amongst the competing amino acids, it was determined that ternary complexes play an important role in the model, with asparagine, histidine and alanine being the most important ligands.

(848) Graham, R. D. (1979). Transport of copper and manganese to the xylem exudate of sunflower. Plant, Cell and Environment 2(2): 139-143.
Absorption of Cu and Mn by sunflower roots from sol. cultures of varying composition was followed by measuring the concentrations of the metals appearing in whole roots, root cell sap and xylem exudate. Total Cu in the fibrous roots was linearly related to the concentration of Cu in the external sol., but the concentration of Cu released to the xylem exudate was buffered somewhat against the changes made externally. No such buffering was observed for Mn. A Cu-sensitive electrode, responsive only to free cupric ions, was used in conjunction with total Cu analysis by atomic absorption spectrophotometry to show that little of the Cu (usually <1%) existed as a free ion in any phase of the system. Cu in the xylem exudate may be strongly complexed. An electron paramagnetic resonance spectrum of the xylem exudate indicated that Mn probably was a free divalent ion. Calculation of the electrochemical potential gradient for free cupric ions showed that no special metabolically-linked mechanism need be postulated to account for absorption of Cu (or Mn) other than that necessary to maintain the transmembrane potential.

(849) Arnold, M. A. and D. K. Struve (1989). Cupric carbonate controls green ash root morphology and root growth. HortScience 24(2): 262-264.
Dormant 1-year-old bare-root Fraxinus pennsylvanica seedlings were grown in CuCO3-treated plastic containers (the inner surfaces of which were painted with 100 g CuCO3/litre flat-white exterior acrylic latex paint) and untreated plastic containers to study the effects of CuCO3 on root growth. Plants grown in CuCO3-treated containers were nearly 50% taller than plants grown in untreated containers (119 vs. 81 cm, respectively). In roots contacting CuCO3-treated surfaces the elongation rates fell to almost zero within 3 days. However, they were not killed and resumed elongation rates similar to those of non-CuCO3-treated roots within 3 to 6 days of release from CuCO3. Roots contacting CuCO3-treated surfaces were 50% shorter (14 vs. 28 cm), branched closer to the root apex (2.4 vs. 4.7 cm), and formed more higher-order lateral roots (10.6 vs. 7.6) than roots contacting untreated container surfaces. Seedlings grown in CuCO3-treated containers had higher Cu concentrations in main roots, root tips, stems, and foliage than seedlings grown in untreated containers.

(850) Aldrich, J. H. and J. G. Norcini (1994). Copper hydroxide-treated pots improve the root system of bougainvillea cuttings. 107th Annual meeting of the Florida State Horticultural Society, Orlando, Florida, USA, 30 October 1 November 1994 107: 215 - 217.
The responses of root systems of Barbara Karst bougainvillea (Bougainvillea X buttiana) cuttings to 100 g Cu(OH)2/litre in latex paint applied to the interior surface of square 66-, 120- or 280-ml plastic pots were determined. Cuttings (10 cm long; 3-5 nodes; 2 leaves) were scored on opposite sides and dipped in K-IBA at 6000 mg/litre for 3 s on 16 Apr. 1993. Cuttings were placed in treated or untreated pots that contained a 1:1 Canadian sphagnum peat:coarse perlite (v/v) medium. The pots were completely randomized in a 3 X 2 factorial design. The cuttings were rooted under intermittent mist (9 s every 5 min) for 12 h/day in a greenhouse (20% shade). Cuttings rooted in Cu(OH)2-treated containers exhibited no root circling and a more compact, well-branched root system than cuttings rooted in untreated containers. However, root fresh weight was reduced by the Cu(OH)2 treatment. The number of primary roots, root fresh and dry weight decreased with increasing container volume.

(851) Maynard, B. K. and W. A. Johnson (1997). Controlling rooting-out of B&B nursery stock during storage. Journal of Environmental Horticulture 15(2): 111-114.
Cupric hydroxide formulated as Spin OutTM (7% Cu(OH)2 in a latex carrier, w/w) was used to prevent rooting-out of Taxus X media cv. Densiformis root balls into surrounding mulch or soil during storage over a 4-month period. Treatments included: painting the bottom of the root ball with Spin OutTM, setting the root ball on Spin OutTM-treated burlap or on untreated burlap, and rewrapping the root ball with Spin OutTM-treated burlap or burlapping using Spin OutTM-treated burlap before mulching. All treatments provided some control of rooting-out after 12-16 weeks' storage. The most effective treatments were (1) in unmulched situations, setting the root ball on Spin OutTM-treated burlap (92% reduction in root count after 16 weeks), and (2) in mulched situations, either rewrapping or burlapping with Spin OutTM-treated burlap (90% and 86% reduction in root count, respectively, after 16 weeks). Using Spin OutTM-treated burlap to prevent rooting-out during storage can reduce the incidence of re-balling and root removal prior to shipping and planting stored balled and burlapped (B&B) nursery stock.

(852) Svenson, S. E. and D. L. Johnston (1995). Rooting cuttings in cupric hydroxide-treated pots affects root length and number of flowers after transplanting. HortScience 30(2): 247-248.
Stem tip cuttings of Evolvulus glomeratus Nees & Mart., E. tenuis Nees & Mart., Lantana camara L. 'Dallas Red,' and L. montevidensis Briq. 'Alba' were rooted for 6 weeks in 57-mm-diameter (150 ml) square pots. Before rooting, interior surfaces of half of the pots were treated with 100 g Cu(OH)2/liter, while remaining pots were left untreated. Elongation of adventitious roots stopped when root tips came in contact with a Cu(OH)2-treated surface. Cupric hydroxide treatment reduced total root length and the length of the longest root for all four species, but did not influence root, shoot, or total plant weight. One month after transplanting to 150-mm-diameter (1.2 liter) hanging baskets, plants moved from Cu(OH)2-treated pots had more flowers than those transplanted from nontreated pots. Applying Cu(OH)2 to interior surfaces of pots used for propagation prevented root deformation, reduced root length, and increased flowering following transplanting.

(853) Arnold, M. A. (1992). Timing, acclimation period, and cupric hydroxide concentration alter growth responses of the Ohio Production System. Journal of Environmental Horticulture 10(2): 114-117.
Quercus rubra was used as a model system to determine the effects of reduced greenhouse and acclimatization phases of the Ohio Production System of container-tree raising for use in the mid-southern region of the U.S.A. Initiation of the greenhouse seedling production phase could be delayed from early Feb. to early Mar. without reducing end-of-season growth. Eliminating the acclimatization phase (under 55% shade cloth outdoors) reduced the % seedling survival from 100% to 87.7%; extending the acclimatization phase beyond 7 days did not improve growth. In another experiment, plants of Taxodium distichum were grown in straight-walled, round, plastic containers painted with 25, 50 or 100 g Cu(OH)2/litre (formulated as Spin Out), in nontreated straight-walled, round containers, in nontreated stepped-pyramid pots, or in stepped-pyramid pots painted with 100 g Cu(OH)2/litre. Either container type treated with 100 g Cu(OH)2/litre effectively

controlled root deformation. Nontreated stepped-pyramid pots reduced root circling, but did not control kinking and matting of roots at container surfaces.

(854) Ruter, J. M. (1994). Growth responses of four vigorous-rooted tree species in cupric hydroxide-treated containers. HortScience 29(9): 1089.
Cupric hydroxide is often used to reduce root deformation (circling) in container-grown plants. Final plant height, stem diameter and root coverage were evaluated for first-year seedlings of Betula nigra, Platanus occidentalis, Salix babylonica and Taxodium distichum grown in containers with or without cupric hydroxide coating on the inside surface. Cupric hydroxide did not affect height of B. nigra, but reduced the final height of P. occidentalis and T. distichum. Stem diameter of B. nigra was increased 15% by cupric hydroxide, but that of other species was not affected. Root coverage and root circling of all species were reduced by cupric hydroxide.

(855) Beeson, R. C., Jr. and R. Newton (1992). Shoot and root responses of eighteen southeastern woody landscape species grown in cupric hydroxide-treated containers. Journal of Environmental Horticulture 10(4): 214-217.
Eighteen species of woody landscape trees commonly produced in the southeastern USA were grown in 3.8-litre, round, plastic containers painted on the inside with cupric hydroxide (7% w/w) or in untreated control containers. Plants were evaluated for Cu toxicity symptoms, root circling and growth. No Cu toxicity symptoms were observed. Root circling and deflection were completely controlled except in Taxodium distichum and Quercus laurifolia. Even for these two species, root circling was less in the Cu-treated than control containers. Root circling was not controlled in the bottom of square containers designed to prevent root circling for a sub-plot of 6 species. For a few species, some treatment effects on plant growth were observed, though most would be commercially insignificant.

(856) Svenson, S. E., D. L. Johnston, et al. (1995). Shoot and root responses of eight subtropical species grown in cupric hydroxide-treated containers. HortScience 30(2): 249-251.
The effect of Cu(OH)2 applied to interior container surfaces on shoot and root responses was evaluated on eight species cultivated in subtropical regions. Species studied were Cedrela odorata L.; Eriobotrya japonica (Thunb.) Lindl.; Leea coccinea Planch.; Peperomia serpens (Swartz.) Loud.; Peperomia obtusifolia (L.) A. Dietr.; Radermachera sinica (Hance) Hensl.; Schefflera actinophylla (Endl.) Harms; and Swietenia mahagoni (L.) Jacq. No foliar Cu toxicity symptoms developed on any species during the study. Swietenia mahagoni seedlings grew faster in height and had larger shoot: root ratios when grown in Cu(OH)2-treated containers than in nontreated containers. Leea coccinea seedlings were taller and produced more shoot dry weight when grown in Cu(OH)2-treated than in control containers. Applying Cu(OH)2 did not influence shoot growth of the other six species studied. Root coverage reduction on the exterior of the rootball in Cu(OH)2-treated containers was excellent for all species studied, and coverage was completely eliminated in three species. Shoot and root responses to Cu(OH)2-treated containers varied among subtropical species, which is consistent with shoot and root responses among temperate species.

(857) Svenson, S. E. and D. L. Johnston (1994). Root and shoot responses of ten foliage species grown in cupric hydroxide treated containers. 107th Annual meeting of the Florida State Horticultural Society, Orlando, Florida, USA, 30 October 1 November 1994 publ. 1995: 107: 192-193.
The effects of cupric hydroxide, formulated as SpinOutTM and applied to interior container surfaces, on the root and shoot growth of 10 foliage pot plant species were studied. Species evaluated were Chlorophytum comosum, C. bichetii, Dracaena fragrans cv. Massangeana, Ficus triangularis [F. leprieurii] cv. Variegata, Leea coccinea, Radermachera sinica, Peperomia serpens cv. Variegata, Peperomia obtusifolia, Schefflera actinophylla cv. Amate and Spathiphyllum cv. Supreme. Root balls were evaluated to determine the degree of control of root growth at the container-medium interface. Cupric hydroxide completely eliminated root growth at the container-medium interface in P. obtusifolia and R. sinica. Control of root growth for the remaining species was excellent. Shoot growth was unaffected except in L. coccinea and Spathiphyllum cv. Supreme; cupric hydroxide increased it in the former and reduced it in the latter.

(858) Brass, T. J., G. J. Keever, et al. (1997). Styrene-lined and copper-coated containers affect production of Cornus florida. Journal of Environmental Horticulture 15(3): 131-134.
Response of C. florida cultivars Barton's White and Weaver's White to styrene lining and copper hydroxide coating of 10.3-litre black plastic containers was evaluated in 1993 and 1994 in Alabama. After the first growing season, plants were either left in their original containers or repotted into unlined 23.3-litre containers. Copper hydroxide reduced root circling in both cultivars in containers; however, root dry weight of plants grown in copper-treated containers was reduced during the first season. Copper-treated containers resulted in less growth in height when plants were left in their original container during the second growing season and less trunk diameter growth of plants repotted into 23.3-litre containers. In the absence of copper, more surface root coverage and less surface root dieback occurred with plants grown in styrene-lined containers. Both cultivars grown the second season in their original styrene-lined containers exhibited greater height increases than those in unlined containers. After being repotted into 23.3-litre containers, both cultivars originally grown in styrene-lined containers exhibited greater trunk diameter growth than those in unlined containers.

(859) Martin, C. A. and S. Bhattacharya (1995). Effects of cupric hydroxide-treated containers on growth of four southwestern desert landscape trees. Journal of Arboriculture 21(5): 235-238.
Seedling liners of four southwestern USA desert landscape trees - Acacia smallii, Acacia stenophylla, Cercidium praecox, and Prosopis chilensis - were potted into black polyethylene containers which were either painted on the inner wall with a latex paint containing cupric hydroxide (Cu(OH)2), or were unpainted. Tree seedlings were then grown for five months in an outdoor container production nursery and evaluated for effects of Cu(OH)2-treated containers on tree growth. No foliar copper toxicity symptoms were observed on any species during the study. In comparison with unpainted containers, Cu-treated containers increased root branching frequency, reduced shoot extension, and lowered the number of primary shoot lateral branches of sweet acacia (A. smallii) and shoestring acacia (A. stenophylla). Cu-treated containers also decreased height of shoestring acacia. Chilean mesquite (P. chilensis) grew taller and larger with increased shoot and root dry weights in Cu-treated containers in comparison with those in unpainted containers. However, effects of Cu-treated containers on growth of Chilean mesquite were not related to any changes in root branching frequency. Growth of palo brea C. praecox and root-to-shoot ratios of all four tree species were not affected by Cu-treated containers.

(860) Brass, T. J., G. J. Keever, et al. (1997). Production of six woody landscape plants in copper-coated and styrene-lined containers. Journal of Environmental Horticulture 15(2): 73-76.
Growth of Rhododendron cv. Hershey's Red, Magnolia

grandiflora, Ilex X meserveae cv. Blue Princess, Pittosporum tobira, Gardenia jasminoides cv. August Beauty and Nerium oleander was evaluated for 8 months in 3.8-litre containers treated or not treated with copper hydroxide (Cu) and with or without a styrene lining. Plants were then repotted into 10.3-litre untreated containers to determine treatment effects on root regeneration and shoot growth. In addition, Rhododendron cv. Hershey's Red, Gardenia jasminoides cv. August Beauty and Ilex X meserveae cv. Blue Princess were planted in the ground to evaluate root regeneration and shoot growth during landscape establishment. All species tested had less root growth at the substrate-container interface at the end of the first growing season when grown in Cu-treated containers. Other growth parameters measured (height, trunk diameter, growth index) varied among species in response to Cu treatment. One growing season (11 months) after repotting into 10.3-litre containers, all species had less surface root coverage when the original 3.8-litre container was Cu treated. Dry weights of newly generated roots outside the original rootball of repotted or transplanted plants were not affected by Cu or styrene treatment, except for a lower root dry weight in I. meserveae when previously grown in +Cu containers. After repotting into larger containers, shoot growth in response to Cu was species-dependent. Transplanted Rhododendron had a lower growth index after transplanting from +Cu containers than from -Cu containers. Growth index of G. jasminoides was increased after repotting into 10.3-litre containers from 3.8-litre, styrene-lined containers; surface root coverage 5 months after repotting also was increased when plants were previously grown in styrene-lined containers. N. oleander, I. meserveae and M. grandiflora previously grown for 8 months in 3.8-litre styrene-lined containers without Cu all had more surface root coverage after being grown for 11 months in 10.3-litre containers than plants grown in unlined containers.

(861) Arnold, M. A. (1996). Mechanical correction and chemical avoidance of circling roots differentially affect post-transplant root regeneration and field establishment of container-grown shumard oak. Journal of the American Society for Horticultural Science 121(2): 258-263.
Quercus shumardii seedlings were grown for 3 or 7 months in 2.3-litre black plastic containers. Containers were either treated or not on their interior surfaces with 100 g Cu(OH)2/litre latex carrier. Trees were transplanted in summer or autumn and 4 treatments were used at each transplant date: unpruned seedlings from Cu(OH)2-treated or untreated containers and seedlings from untreated containers on which 2 mechanical root pruning techniques were used (traditional severing of circling roots on the rootball periphery or splitting and splaying the bottom two-thirds of the rootball (butterfly pruning)) at transplant. Traditional root pruning severed more small roots (diameter _0.5 mm) than butterfly pruning. During the first 21 days following transplant most root regeneration was via elongation of intact root tips. Cu(OH)2-treated seedlings regenerated substantially more roots _1.0 mm in diameter and a greater root mass than mechanically root pruned or unpruned seedlings. Both mechanical pruning techniques resulted in greater predawn water stress during immediate post-transplant (21 days) establishment in Oct. than seedlings chemically treated to prevent circling root development. Treatments that severed more roots and/or removed greater root mass were associated with decreased field performance and increased post-transplant water stress. Increased numbers of small- to medium-diameter new roots were associated with reduced post-transplant water stress and improved post-transplant shoot growth. Non-pruned and traditionally root-pruned seedlings grew little during the first 2 post-transplant growing seasons regardless of transplant date. Butterfly pruning resulted in severe dieback. Cu(OH)2-treated seedlings were the only ones to exhibit a gain in height or stem diameter after 2 years in the field.

(862) Schinner, F. A., R. Niederbacher, et al. (1980). Influence of compound fertilizer and cupric sulfate on soil enzymes and CO2-evolution. Plant and Soil 57(1): 85-93.
In a forest nursery soil litter decomposition was inhibited by additions of a compound (NPK) fertilizer and/or cupric sulphate. Urease and xylanase activities were markedly reduced after six weeks, while cellulase and invertase activities were little affected. Intracellular dehydrogenase activity increased following fertilizer application to soil, but decreased rapidly after soil treatment with cupric sulphate.

(863) Kahle, H. (1993). Response of roots of trees to heavy metal. Environmental and Experimental Biology 33(1): 99 - 119.
The heavy metal burden with which tree roots have to cope originates either from natural metalliferous soils or from continuous man-made inputs to forest ecosystems. Considering the interconnections with external factors in the rhizosphere, the responses of roots of various tree species t-- root-applied Pb, Cd, Zn, Cu, Ni, Mn, and Hg are reviewed. Data on stimulation, but mainly on the depression, of growth parameters such as root elongation, biomass production, root initiation and root hair formation in relation to the architecture of the whole root system, are derived from dose-response experiments with moderate or excess metal supply to young trees using water, sand or soil culture. Assessment of heavy metal toxicity also includes results on the disturbance to the mineral nutrition of tree roots. Effective metal levels from experiments are compared to field - concentrations in forest soils and trees. Counteracting strategies such as the phytochelatin response, tolerance mechanisms, or raising of the rhizosphere pH are discussed with respect to tree species and include the crucial role of mycorrhizae.

(864) Vizarova, G. and Z. Holub (1994). Effect of cupric sulphate on the root system of Agrostis stolonifera L. Biologia Bratislava 49(6): 893-898.
The effects of 3, 10, 50, 100 or 400 mg CuSO4/litre of Knop's nutrient medium on the growth of the root system of A. stolonifera, the accumulation of Cu2+ ions in the root system, and changes in free endogenous ABA and cytokinins were examined. High concentrations of Cu2+ ions markedly inhibited root growth. This was correlated with decreases in cytokinins and increases in ABA. Root Cu2+ uptake was positively correlated with the concentration of CuSO4 in the nutrient medium.

(865) Burdett, A. N. and P. A. F. Martin (1982). Chemical root pruning of coniferous seedlings. HortScience 17(4): 622-624.
Conifer seedlings of 10 species from 6 genera were raised in containers coated on the inside with basic cupric carbonate in latex paint. The copper paint prevented lateral roots from growing down or around the container wall. After transplanting, the chemically root-pruned stock was generally capable of vigorous root growth. The effectiveness of the chemical root pruning treatment varied with species, container size, growing medium, and the concentration of cupric carbonate in the coating.

(866) Arnold, M. A., D. L. Airhart, et al. (1993). Cupric hydroxide-treated containers affect growth and flowering of annual and perennial bedding plants. Journal of Environmental Horticulture 11(2): 106-110.
Cultivars of 4 annual species (Celosia cristata [C. argentea var. cristata] cv. Castle Pink, Impatiens wallerfi]ana cv. Super Elfin Red, Pelargonium X domesticum cv. Ringo Scarlet and Tagetes patula cv. Discovery Yellow) and 2 perennial species (Chrysanthemum [Leucanthemum] X superbum cv. Alaska and Coreopsis lanceolata cv. Early Sunrise) were grown in a greenhouse for about 40 days in 0.3-litre plastic containers that had been treated on their inner surfaces with 25, 50 or 100 g

Cu(OH)2/litre, formulated as Spin Out. Control plants were grown in untreated containers. Following greenhouse production and a 4-day acclimatization period in a shade-house, the plants were transplanted to a field plot. Cupric hydroxide concentrations that resulted in practical levels of control and/or elimination of root deformation (circled, kinked and matted roots at container wall/media interfaces) were species-dependent; 100 g/litre reduced, but did not eliminate, root deformation in T. patula and L. superbum, whereas 25 g/litre almost completely eliminated root deformation in P. domesticum. During greenhouse production, Cu(OH)2 treatments of 50 or 100 g/litre increased the vegetative growth of C. cristata and increased the number of flowers on I. walleriana, compared with controls. After field planting, P. domesticum grown in 50 or 100 g Cu(OH)2/litre-treated containers and I. walleriana in 100 g Cu(OH)2/litre-treated containers had increased vegetative growth, compared with controls. The flowering potential of I. walleriana following field planting was increased by the 50 g Cu(OH)2/litre treatment.

(867) Burdett, A. N. (1978). Control of root morphogenesis for improved mechanical stability in container-grown lodgepole pine. CANADIAN JOURNAL OF FOREST RESEARCH 8(4): 483-486.
Lodgepole pine (Pinus contorta) seedlings were raised in containers (Styroblocks) painted with a root-growth inhibitor (exterior latex paint containing 0.1 kg/litre basic cupric carbonate). Contact with this wall coating completely inhibited the elongation of lateral roots, thereby preventing them from growing down or around the container wall. However, when the seedlings were planted, the inhibited lateral roots very quickly resumed growth. Consequently, the trees soon acquired a root system quite similar in basic form to that of a naturally established seedling. (From author's summary)

(868) Hocking, D. (1972). Copper toxicity in container seedlings grown in copper-bottomed flats. Bi monthly Research Notes 28(4): 26.
It has been the practice to spray with copper paint the trays in which containers are stood while rearing seedlings, in order to inhibit growth of roots outside the containers. A comparison of Pinus contorta var. latifolia seedlings grown in this way with controls from trays painted with non-copper paints, showed that the former were significantly smaller and that the Cu content of their roots was about 10 times that of the controls. It is recommended that unwanted root growth should be controlled by routine root-pruning.

(869) Wenny, D. L., Y. Liu, et al. (1988). First year field growth of chemically root pruned containerized seedlings. New Forests 2(2): 111-118.
Containers deform seedling root systems and have a potential to inhibit tree growth after outplanting. Pinus ponderosa, P. monticola and Pseudotsuga menziesii were grown in containers coated with latex paint containing different concn. of cupric carbonate and outplanted in a forest. Treatment effects on seedling growth and root morphology were determined after one growing season in the field. Seedling height was unrelated to treatment and stem diameter was not significantly affected (p _0.05). New root growth in the upper portion of the root plug was significantly increased (p _0.05). The optimal concn. of cupric carbonate for seedling root growth in the upper portion of the root plug was estimated by multiple regression.

(870) Wenny, D. L. and R. L. Woollen (1989). Chemical root pruning improves the root system morphology of containerized seedlings. Western Journal of Applied Forestry 4(1): 15-17.
Douglas fir (Pseudotsuga menziesii), ponderosa pine (Pinus ponderosa) and western white pine (Pinus monticola) were chemically root pruned with cupric carbonate (CuCO3) by coating 66 cm3 containers with latex paint containing CuCO3 at 0, 30, 100, or 300 g/litre. Seedlings were potted after one growing season, and a standard root growth potential test was applied: the number and length of new roots >1 cm in length were measured monthly for 6 months during the growing season. Root systems increased in total root number and length, especially in the upper segments of the root plug, as a result of chemical root pruning. Seedling ht. and caliper were unaffected by the cupric carbonate treatments during the production phase, and a latex paint carrier did not decrease seedling growth.

(871) Latimer, J. G., T. Ito, et al. (1995). Tomato and pepper transplant response to cupric hydroxide treatment of production flats. Hydroponics and transplant production Kyoto: Japan, 21-27 August 1994. Acta-Horticulturae. 1995 No. 396, 305-312.
Seeds of tomato cv. Sunny and Capsicum annuum cv. Jupiter were sown in flats treated with 0, 25, 50, 100 or 150 g cupric hydroxide/litre. At 36 days after sowing (DAS), the shoot and root lengths of tomato seedlings were reduced by all rates of cupric hydroxide, but shoot and root DWs were not affected. Shoot and root DWs and root length of Capsicum seedlings at 42 DAS were reduced by all rates of cupric hydroxide, but stem length was generally increased. Plants were then transplanted into sand in the greenhouse and grown with or without water stress for 15 days, with shoot and root DW data collected at 3-day intervals to determine the relative growth rate (RGR). In both species, water stress reduced root and shoot growth. The cupric hydroxide treatment had no effect on tomato shoot and root RGR. The shoot and root RGR of Capsicum without water stress were highest in plants from flats treated with 50 or 100 g cupric hydroxide/litre. Under stress conditions, plants from flats treated with 100 or 150 g/litre had the highest shoot and root RGRs.

(872) Armitage, A. M. and P. M. Gross (1996). Copper-treated plug flats influence root growth and flowering of bedding plants. HortScience 31(6): 941-943.
A copper hydroxide formulation (0, 3.5, 7 or 11% Cu) was applied to plug trays before sowing seeds of Impatiens [walleriana] cv. Accent Red, Pelargonium Xhortorum cv. Scarlet Elite and Petunia Xhybrida cv. Ultra White to investigate the influence of the formulations on ease of transplanting, root growth and shoot growth. These factors were also investigated in Cu-treated seedling plugs held past the optimal transplanting stage. Root spiralling and seedling height at transplanting were reduced for all taxa grown in Cu-treated trays, at all concentrations, compared with seedlings from non-treated trays. Root weight and shoot weight responses to Cu treatments at transplanting and at flowering varied among taxa. Mature heights of all taxa were unaffected by Cu treatment; however, flowering date was delayed for impatiens and pelargoniums transplanted at the optimal time from Cu-treated trays. In general, petunias displayed little response to Cu treatment. Root spiralling was reduced and plugs were removed more easily from Cu-treated than from control trays stored for 2 weeks in the greenhouse, but flowering time was delayed by 12 days for impatiens and petunias and 21 days for geraniums, regardless of Cu concentration.

(873) Brass, T. J., G. J. Keever, et al. (1996). Styrene-lined and copper-coated containers affect production and landscape establishment of red maple. HortScience 31(3): 353-356.
Growth response of Acer rubrum cultivars October Glory and Northwood to styrene lining or copper hydroxide coating of 23.3-litre black plastic containers was evaluated (in Alabama, USA). After the first growing season, plants were left in their original container, repotted into 51.2-litre non-treated containers or

transplanted into the landscape. Copper hydroxide effectively reduced root circling in both cultivars at the medium-container interface during the first year of production, but was less effective during the second growing season. Repotting from copper-treated containers into 51.2-litre containers or transplanting into the landscape resulted in more fibrous root development and enhanced root generation outside the original rootball relative to transplanting from non-treated containers. However, when copper hydroxide was applied to styrene lining, root regeneration after transplanting was reduced. Roots of plants grown in styrene-lined containers covered the medium-container interface more thoroughly than those in non-lined containers, but height, trunk diameter and root regeneration were similar. October Glory had a larger trunk diameter, more branching, and better root regeneration than Northwood.

(874) Arduini, I., L. Godbold Douglas, et al. (1994). Cadmium and copper change root growth and morphology of Pinus pinea and Pinus pinaster seedlings. Physiologia Plantarum 92(4): 675-680.
Heavy metal loads in forest soils have been increasing over time due to atmospheric inputs. Accumulation in the upper soil layers could affect establishment of seedlings and forest regeneration. Mediterranean species show a high initial root development, allowing seedlings to reach the moisture of deeper soil layers. In the present work seedlings of stone pine (Pinus pinea L.) and maritime pine (Pinus pinaster Ait.), were grown in culture solution supplied with 0.0, 0.1, 1 or 5 mu-M CdSO-4 or with 1 mu-M CdSO-4 and 1 mu-M CuSO-4 combined. In both species tap-root elongation was drastically reduced in the 5 mu-M Cd-2+ and in the (Cd-2+ +Cu-2+) treatments. A supply of 0.1 or 1 mu-M Cd-2+, however, enhanced root elongation in Pinus pinea without significantly influencing root elongation in Pinus pinaster. In both species the root density (weight per unit length) and the width of the cortex increased in response to Cd-2+ exposure. In Pinus pinaster the mitotic index decreased at the higher Cd-2+ concentrations and when Cd-2+ and Cu-2+ were combined. The data suggest that cell elongation is more sensitive to Cd-2+ than cell division. The number and length of the lateral roots were also affected by Cd-2+ treatment to a higher degree in Pinus pinaster than in Pinus pinea, reflecting the different Cd-tolerance of the two species.

(875) Heale, E. L. and D. P. Ormrod (1982). Effects of nickel and copper on Acer rubrum, Cornus stolonifera, Lonicera tatarica, and Pinus resinosa. Canadian Journal of Botany 60(12): 2674-2681.
Acer rubrum, Cornus stolonifera and Lonicera tatarica cuttings and Pinus resinosa seedlings were grown in a controlled environment in aerated liquid culture with 2 or 10 mg l-1 Ni2+ or 4 or 20 mg l-1 Cu2+ singly or in combination (2 and 4 mg l-1 or 10 and 20 mg l-1). Injury symptoms included marginal and interveinal chlorosis, alteration of leaf pigmentation, severe leaf drop and abnormally small leaves. With increasing metal levels, root tissues became severely discoloured, lateral roots were few in number, stunted and thickened, and bulbous root tips developed. Growth and development of Lonicera were retarded in all metal treatments while Pinus was unaffected and Acer and Cornus were retarded only at the highest Cu concentration. Metal accumulation in tissues generally increased with increasing Ni and Cu concentrations in the nutrient solutions, but tissue concentrations varied according to species, metal and tissue analyzed.

(876) Golan Goldhirsh, A., A. Mozafar, et al. (1995). Effect of ascorbic acid on soybean seedlings grown on medium containing a high concentration of copper. Journal of Plant Nutrition 18(9): 1735-1741.
In a hydroponic culture experiment, soyabean seedlings were exposed to 0 or 0.5 mmol Cu/litre as cupric sulfate and 0-5 mmol ascorbic acid/litre. The toxic effect of Cu mostly affected root growth. Cu uptake was significantly decreased by 5 mmol ascorbic acid. The effect was due mainly to reduction of Cu uptake by roots. The toxic effect of high Cu concentrations was observed after 3-5 d.

(877) Wenny, D. L. (1988). Growth of chemically root-pruned seedlings in the greenhouse and the field. Proceedings, combined meeting of the Western Forest Nursery Associations: Western Forest Nursery Council, Forest Nursery Association of British Columbia and Intermountain Forest Nursery Association 1988(Vernon): British Columbia [coordinated by Landis, T.D.]. General-Technical-Report --Rocky-Mountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service. 1988, No. RM-167, 32-37.
Seedlings of ponderosa pine (Pinus ponderosa), western white pine (P. monticola) and Douglas fir (Pseudotsuga menziesii) were raised in containers with unpainted cavities (control) or with a latex paint coating containing cupric carbonate. Shoot growth was unaffected by treatment, but laterals were pruned at the plug wall on seedlings grown with CuCO3. In tests of root growth potential, treated seedlings developed more new roots in the top and middle plug zones (a more natural root distribution) than control seedlings. Treatment with CuCO3 did not increase survival or height growth 3 yr after planting on the University of Idaho Experimental Forest.

(878) Arnold, M. A., D. C. Wilkerson, et al. (1997). Impacts of copper leaching from copper hydroxide-treated containers on water recycling, nursery runoff, and growth of baldcypress and corn. Journal of the American Society for Horticultural Science 122(4): 574-581.
Studies were conducted using Zea mays and Taxodium distichum seedlings as model systems to study Cu leaching from Cu(OH)2-treated containers. Initial experiments developed Cu toxicity curves (as CuSO4) in an inorganic (sand) or organic (bark-sand) medium with single (acute) or multiple (chronic) applications. A second pair of experiments investigated short-term (35 days) Cu accumulation and plant responses to irrigation with water (125 ml/plant per day) recycled through a fixed reservoir volume (9.5 litres) from 0.7-litre Cu(OH)2-treated containers filled with inorganic or organic medium. Finally, plant responses and Cu leaching were monitored during growth in 2.3-litre Cu(OH)2-treated containers filled with 2 organic media fertigated with high (8.0) or low (6.5) pH solutions. Different Cu(OH)2 concentrations and application methods were tested. Leachate data from the latter studies were used to calculate potential Cu concentrations in nursery runoff using various water application methods and pot spacings. Expression of Cu toxicity symptoms depended on exposure, concentration and medium for each species. Plants subjected to chronic exposure and grown in an inorganic medium developed toxicity symptoms at lower doses than plants subjected to acute exposure and grown in an organic medium. Several measures of plant growth for both species increased with increasing concentration of Cu(OH)2 in treated 0.7-litre containers, but not in 2.3-litre containers. Plants in Cu(OH)2-treated containers seldom exhibited Cu toxicity symptoms in shoot tissues, even with an inorganic medium. Soluble Cu content of the recycled solution from Spin Out-treated containers increased slightly (<1.2 mg/litre) during the 35-day experiment. Longer-term studies with non-recycled leachate from 2.3-litre containers indicated that Cu leaching increased after 60-90 days. Cu leaching was greater with the combination of applied solution of pH 6.5 and bark-sand-peat medium than with the combination of applied solution of pH 8.0 and bark-sand medium, and increased with greater concentrations of Cu(OH)2 in container wall treatments or when containers were filled before the latex carrier was dried. Calculations of potential nursery runoff indicated that the levels of

soluble Cu in effluent for most concentrations and spacings projected were below Environmental Protection Agency action levels for potable water (1.3 mg/litre) when overhead irrigation was used.

(879) Ruter, J. M. (1994). Evaluation of control strategies for reducing rooting-out problems in pot-in-pot production systems. Journal of Environmental Horticulture 12(1): 51-54.
Research has shown that a problem in pot-in-pot (PIP) production systems has been the growth of roots out of the planted container, through holes in the holder pot and into the surrounding soil. A study was conducted with Lagerstroemia indica X L. fauriei cv. Acoma to evaluate methods for reducing rooting-out problems in a PIP production system. The products tested were BiobarrierTM, a geotextile fabric impregnated with trifluralin; Root ControlTM fabric bag material; and Spin OutTM, a commercial formulation of copper hydroxide (7.1%) in latex paint. BiobarrierTM reduced plant height, shoot DW, percentage root DW outside of the planted container and total biomass compared with the non-treated control. For the control, 7.1% of the total root DW was found between the holder pot and planted container compared with 0.2% for the BiobarrierTM treatment. When the holder pot and planted container or the planted container and Root ControlTM fabric were both treated with Spin OutTM, plant height and shoot DW were reduced. Spin Out TM reduced root circling on the sidewalls of the planted containers but not on the bottom of the containers. All treatments except the control reduced rooting-out to a degree which allowed for the manual harvesting of the planted container from the holder pot after 7 months in the field.

(880) Arnold, M. A., R. D. Lineberger, et al. (1994). Copper compounds influence in vitro rooting of birch microcuttings. Journal of the American Society for Horticultural Science 119(1): 74-79.
The effects of woody plant medium (WPM) with various formulations and concentrations of Cu+2 on in vitro rooting and subsequent shoot growth of microcuttings of a Betula pubescens X B. papyrifera (birch) clone were monitored for 28 days. Adventitious root initiation and elongation were reduced in magnitude and slowed in development by moderate to high Cu (as cupric sulfate) concentrations, with near zero root regeneration occurring at 157 µM Cu. Shoot growth was also inhibited by 157 µM Cu as cupric sulfate. Copper-toxicity symptoms (senescent leaves, necrotic stems, and bulbous and stunted roots) were significantly increased by moderate to high levels (_79 µM) of Cu as cupric sulfate. Microcuttings responded differently to Cu+2 applied as cupric chloride; root initiation, root elongation, and root branching were increased, and shoot growth was slightly stimulated by moderate concentrations of cupric chloride. No significant increase in Cu-toxicity symptoms was observed at concentrations up to 157 µM Cu as cupric chloride. Cupric acetate and cupric carbonate produced more severe Cu-toxicity symptoms than cupric sulfate. Root regeneration and shoot growth were inhibited and increased Cu-toxicity symptoms were apparent even with low concentrations (39 µM) of Cu as cupric acetate or cupric carbonate. There was little or no effect on root regeneration when the Cu+2 in cupric sulfate was replaced by different cations, i.e., magnesium, calcium, and hydrogen (as sulfuric acid), a result suggesting that the observed responses could be attributed to the Cu+2 concentration. Changes in media pH did not correspond to Cu-toxicity symptoms or alterations in root or shoot growth by the Cu compounds.

(881) Patsikka, E., E. M. Aro, et al. (1998). Increase in the quantum yield of photoinhibition contributes to copper toxicity in vivo. Plant Physiology 117(2): 619-627.
The effect of copper on photoinhibition of photosystem II in vivo was studied in bean (Phaseolus vulgaris cv. Dufrix) plants grown hydroponically in the presence of various concentrations of Cu2+ ranging from the optimum 0.3 µM (control) to 15 µM. The copper concentration of leaves varied according to the nutrient medium from a control value of 13 mg kg-1 dry weight to 76 mg kg-1 dry weight. Leaf samples were illuminated in the presence and absence of lincomycin at different light intensities (500-1500 µmol photons m-2 s-1). Lincomycin prevents the concurrent repair of photoinhibitory damage by blocking chloroplast protein synthesis. The photoinhibitory decrease in the light-saturated rate of O2 evolution measured from thylakoids isolated from treated leaves correlated well with the decrease in the ratio of variable to maximum fluorescence measured from the leaf discs; therefore, the fluorescence ratio was used as a routine measurement of photoinhibition in vivo. Excess copper affected the equilibrium between photoinhibition and repair, resulting in a decrease in the steady-state concentration of active photosystem II centres of illuminated leaves. This shift in equilibrium apparently resulted from an increase in the quantum yield of photoinhibition (PHIPI) induced by excess copper. The kinetic pattern of photoinhibition and the independence of PHIPI on photon flux density were not affected by excess copper. It is concluded that an increase in PHIPI may contribute substantially to Cu2+ toxicity in certain plant species.

(882) Chatfield, J. M. and D. J. Armstrong (1987). Cytokinin oxidase from Phaseolus vulgaris callus tissues. Enhanced in vitro activity of the enzyme in the presence of copper-imidazole complexes. Plant Physiology 84(3): 726-731.
The effects of metal ions on cytokinin oxidase activity extracted from callus tissues of P. vulgaris cv. Great Northern were examined using an assay based on the oxidation of N6-(DELTA2-isopentenyl)-adenine-2,8-3H (i6Ade) to adenine (Ade). The addition of cupric ions to reaction mixtures containing imidazole buffer markedly enhanced cytokinin oxidase activity. In the presence of optimal concn of Cu and imidazole, cytokinin oxidase activity was stimulated more than 20-fold. The effect was enzyme dependent, specific for Cu, and observed only in the presence of imidazole. The substrate specificity of the Cu-imidazole enhanced reaction, as judged by substrate competition tests, was the same as that observed in the absence of Cu and imidazole. Similarly, in tests involving DEAE-cellulose chromatography, elution profiles of cytokinin oxidase activity determined using a Cu-imidazole enhanced assay were identical to those obtained using an assay without Cu and imidazole. On the basis of these results, the addition of Cu and imidazole to reaction mixtures used to assay for cytokinin oxidase activity is judged to provide a reliable and specific assay of greatly enhanced sensitivity for the enzyme. The mechanism by which Cu and imidazole enhance cytokinin oxidase activity is not certain, but the reaction catalysed by the enzyme was not inhibited by anaerobic conditions when these reagents were present. This observation suggests that Cu-imidazole complexes are substituting for O2 in the reaction mechanism by which cytokinin oxidase effects cleavage of the N6-side chain of i6Ade.

(883) Wyatt, J. E. (1998). Tomato transplant production using the float system and cupric hydroxide. HortTechnology 8(3): 366-369.
Comparisons were made between conventional and float system growing methods for tomato (cv. Sunny) transplants and subsequent production. Effects of cupric hydroxide application to the interior surface of plant-growing trays were compared to untreated controls. Tomato transplants grown in the float system had higher fresh and dry weights, were larger after establishment in the field and produced higher early yields of small, medium and large tomatoes than plants grown by conventional methods. Mean fruit weight was higher from conventionally grown transplants early in the season. Total number of fruits and total yield were not affected by transplant production method. Transplants grown in

cupric hydroxide-treated trays were larger and had fewer roots emerging through the bottom of the trays than transplants grown in untreated trays. Cupric hydroxide treatment had no effect on tomato earliness, yield or mean fruit size.

(884) Nikolic, V. (1996). Sea-buckthorn - new prairie fruit. Shelterbelt News(Fall).

(885) Herman, D. E. (1993). Tree of the month: Quercus macrocarpa, bur oak. Arbor age 13(7): 48-49.

(886) Anon. (199?). Fruit-bearing shrubs for multi-purpose shelterbelts and orchards. Indian Head, SK, Agriculture Canada, Prairie Farm Rehabilitation Administration (PFRA).
Trees and shrubs are commonly planted on prairie farms to reduce soil erosion, protect the farmyard from year-round winds and provide habitat for wildlife. However, trees and shrubs can also provide valuable products such as lumber, pulp, fuel wood and fruit. This booklet describes shrubs which are adapted to the prairie climate. Many of the species are suitable for fruit production and multi-use shelterbelts.

Fruit production and processing represent potential business opportunities for many prairie farmers. Sev-eral different marketing opportunities exist including:
fresh and frozen fruit sales, U-pick operations, and sales of jams, jellies, syrups, juices and toppings.

Producing fruit on the prairies has always been a challenge, but with proper management, high quality fruit crops can be grown. An important factor for success is the use of tree and shrub species which are adapted to the prairie climate.

(887) Anon. (1998). US national arboretum develops two hardy maple cultivars. Amercan Nurseryman(March 15): 8.
Both cultivars (Acer rubrum 'Red Rocket' and A. rubrum 'New World' offer aesthetic qualities that make them ideal for city streets and homes in the northeastern and midwestern US. They also show resistance to the potato leafhopper, which has become a serious threat to maple trees. 'Red Rocket' is reported to be hardy to USDA Zone 3 and 'New World' to USDA Zone 4.

(888) Rose, N. (1998). Field notes: Acer truncatum. American Nurseryman 187(5): 94.

(889) Otis, D. R. and P. Podaras (1997). Small maples: little known, seldom grown. American Nurseryman 186(5): 34 - 36, 38, 40 - 45.
Propagation problems have kept dozens of temperate-climate maple species from being noticed by the public. Studies conducted at Cornell University, However, show that many uncommon maples can be propagated with innovative cutting techniques.

(890) Scianna, J. (1997). Field notes: Acer ginnala. American Nurseryman 186(July 15): 114.

(891) Scianna, J. (1998). The secrets out. American Nurseryman 197(April 15): 29 - 30, 32, 34.
USDA Plant Materials Centers recommend hardy oand ornamental woody plants for the west

(892) Ware, G. and F. Miller (1997). Developing better elms. American Nurseryman 186(August 15): 44 - 46, 48 - 49, 51.
Research at the Morton Arboretum indicates that disease- and pest-resistant Asian elm species may be good stree-tree substitutes for American elm

(893) Flint, H. L. (1998). Field notes: Acer mono. American Nurseryman 187(10): 98.

(894) Rose, N. (1998). Field notes: Ampleopsis brevipedunculata 'Elegans'. American Nurseryman 187(August 1): 98.

(895) Schroeder, W. R. (1998). Poplar development at the PFRA Shelterbelt Centre. Shelterbelt News(Spring).

(896) Powell, C. C., Jr. (1982). Wetting agents for pot plants. Florists' Rev 170(4401): 40-41.

(897) Templeton, A. R., D. A. Rodriguez, et al. (1992). ACA-160, a new class of wetting agents for soilless mixes. Adjuvants for agrichemicals. C. L. Foy. Boco Raton, CRC Press: 367-372.
Comparison of ACA-160, a new class of wetting agents, with AquaGro, the industry standard, revealed that the former has superior wetting properties, improved crop safety and better storage performance. It can be used at lower rates than AquaGro (120 vs. 350 ml/m3).

(898) Botacchi, A. C. (1983). Why wetting agents with artificial mixes? [Potting soil conditioners, greenhouse culture]. Conn Greenhouse Newsl Univ Conn Coop Ext Ser(116): 10.

(899) Elliott, G. C. (1992). Imbibition of water by rockwool-peat container media amended with hydrophilic gel or wetting agent. Journal of the American Society for Horticultural Science 117(5): 757-761.
Water retention at effective water-holding capacity (EWHC) and container capacity (CCAP) were measured in 4 potting media (containing peat and hydrophobic or hydrophilic rockwool in the v/v ratios of 2:1 or 1:1) amended with a wetting agent (Aqua-Gro G) and/or a hydrophilic gel (Supersorb C) in pots 12 cm high containing 445 cm3 medium, and irrigated by capillary mat, flood-and-drain, trickle emitter, or overhead sprinkler. Water retention was measured by weighing. Irrigation was continued until EWHC (i.e. net water retention when no weight increase could be obtained by further irrigation) was reached. CCAP (i.e. net water retention following 24 h saturation and 24 h free drainage) was measured at the end of each experiment. Irrigation method and medium amendments significantly affected EWHC. The order of irrigation treatment effects on EWHC was sprinkler _ trickle > flood and drain _ mat. Hydrophilic gel increased both EWHC and CCAP, while the wetting agent increased EWHC but decreased or had no effect on CCAP. Significant interactions of gel and wetting agent were observed in some media. EWHC was less than CCAP in all treatments, and EWHC was correlated with CCAP more closely with trickle emitter and overhead sprinkler irrigation than with capillary mat and flood-and-drain irrigation.

(900) Blodgett, A. M., D. J. Beattie, et al. (1993). Hydrophilic polymers and wetting agents affect absorption and evaporative water loss. HortScience 28(6): 633-635.
A plantless system using subirrigation was developed to measure water absorption and loss in soilless media amended with hydrophilic polymers, a wetting agent, or combinations of these amendments. Peat-perlite-vermiculite and bark-peat-perlite controls achieved 67% and 52% of container capacity, resp., after 20 daily irrigation cycles. Maximum water content of amended media was 78% of the container capacity. Addition of a hydrophilic polymer only did not increase significantly the total water content. Adding a wetting agent increased water absorption in both media. However, with combinations of hydrophilic polymer and wetting agent the media absorbed more water than with the wetting agent alone. More extractable water was removed from media containing wetting agent. Water loss rate by evaporation

was not affected significantly by medium type, hydrophilic polymer, wetting agent, or any combination of these variables.

(901) Bhat, N. R., T. L. Prince, et al. (1992). Rooted cutting establishment in media containing wetting agent. HortScience 27(1): 78.
Rooted cuttings of chrysanthemum cv. Bright Golden Anne, Pelargonium cv. Your's Truly, Impatiens walleriana and poinsettia cv. Brilliant Diamond were planted in media consisting of sphagnum peat and vermiculite (1:1) blended with the wetting agent Aqua-Gro 'G' (polyoxyethylene esters of cyclic acid (47%) + polyoxyethylene ethers of alkylated phenols (47%) + silicone antifoam emulsion (6%)) at 0, 0.23, 0.47, 0.94, 1.88 or 3.76 kg a.i./m3. The wetting agent at all rates had no effect on cutting establishment or root growth of chrysanthemum or Pelargonium. Poinsettia cuttings established well with all concentrations of the wetting agent used, but plant height, plant width and root growth assessed 4 weeks after planting decreased linearly with wetting agent concentration. Impatiens cuttings were the most sensitive to the wetting agent. Although initial establishment of the cuttings was not affected, subsequent root and shoot growth was severely restricted with wetting agent rates above 0.94 kg/m3.

(902) VanEs, H. M. (1990). Soil wetting agents: useful soil amendments or snake oils. St Lawrence County Agriculture News 79(5): 10.

(903) Wells, J. (1980). Wetting agent gives nursery grower positive, lasting results. Am Nurseryman 151(11): 10-11.
WETTING AGENTS have been used in the agricultural industry for many years. However, it was not until 1968 that our nursery was first ac-quainted with this product.
During a trade show, at which our business is regularly represented, a man asked if our nursery was interested in using less fertilizer and water, and growing better plants at the same time. When I expressed scepticism at this possibility, the salesman presented some convincing data that further at-tracted my interest. The salesman who introduced this product was affiliated with Aquatrols Corp. of America, Pennsauken, NJ. The company's product, Aqua-Gro wetting agent, was going to improve our operation by making more water and nutrients available to our crop at far less effort, he said.

(904) Powell, D. (1987). Water absorbants vs. wetting agents--what's the difference. Am Nurseryman 165(12): 59-61.
WATER ABSORBANT, wetting agent, surfactant, hydrophilic polymer, wetter, moisture-holding enhancer, penetrant, super absorbant, soil mois-turizer, hydrogel - are these word. interchangeable for the same material? No. And the differences are very im-portant as to what can be accomplished in a growing medium.
All of these terms refer to two dis-tinct types of products: water absor-bants and wetting agents. Both work with water, both affect the availability of water to root-zone areas, and both influence the frequency of irrigation. The manufacturers also make similar product claims. Confusion between the two is understandable, and disastrous results can happen when using the wrong product.
The difference between the two products is that one holds water while the other moves it. This is an important distinction because the consequences of holding water when you want to move it or of moving water when you want to hold it are not pleasant to ponder. Each type does its job and can complement the other. Professional plant managers need to know the differences between the two so they can use the right prod-uct at the right time.

(905) Fenster, W., G. Randall, et al. (1978). Effect of Wex [a wetting agent which is claimed to increase the yield of various field crops by aiding soft nutrient availability] on crop yields [Wheat, soybeans]. Soil-Ser-Minn-Univ-Agric-Ext-Serv 103(March): 264 - 265.

(906) Yeager, T. H., R. D. Wright, et al. (1983). Comparison of pour-through and saturated pine bark extract N, P, K, and pH levels. Journal of the American Society for Horticultural Science 108(1): 112-114.
The pour-through (PT) method of nutrient extraction, which involves pouring water on the container media surface and collecting the extract (leachate), was compared with the saturated soil extract (SSE) method for a 100% pine bark medium at container capacity. The data obtained indicated the PT method to be an alternative to the SSE method for nutrient extraction from a pine bark medium.

(907) Mathers, H. (1998). Water quality: what you should know about salinity. The Digger(May): 38 - 39.

(908) Mathers, H. (1998). Water quality: thinking about pH and alkalinity. The Digger(June): 34 - 35, 37.

(909) Houseworth, L. D. (1998). pH balanced. American Nurseryman 187(May 1): 44 - 45.
Nursery professionals must obtain a balanced pH in their spray ater in order to optimize the performance of pesticide applications

(910) Rose, M. A., J. Peterson, et al. (1995). The Ohio State University water quality assessment program. Ornamental Plants - A Summary of Research 1993 - 1994. M. A. Rose and J. A. Chatfield. Wooster, Ohio, Ohio State Univ., Ohio Agricultural Research and Development Center: 13 - 15.

(911) Swanson, B. T. (1984). Irrigation water quality affects a plant's health and salabitliy. American Nurseryman 159(10): 67 - 69.

(912) Fitzpatrick, G. E. and S. D. Verkade (1987). Monitor your irrigation supply. Am Nurseryman Ill.(American Nurseryman Publishing Co. Jan 15): 1987.

(913) McNamara, S. (1998). Effect of soil pH on Betula sp. Landscape Plant News 9(3): 14 - 15.

(914) Gilliam, C. H., J. T. Eason, et al. (1985). Effects of soil pH on four field-grown nursery crops. Journal of Environmental Horticulture 3(3): 136-139.
Four woody nursery crops were grown for 3 years (1981-1983) in plots with varying pH levels. Greater growth of Compacta' Japanese holly and Foster's holly occurred in 1981 and 1982 at lower pH levels (4.1-5.8). However, Mn phytotoxic symptoms appeared on 'Compacta' Japanese holly during the fall of 1982. Foliar Mn levels of all 4 species exceeded 2500 ppm when grown at the lowest pH level, with the exception of Foster's holly in 1983. Growth of 'Nellie R. Stevens' holly was not affected by pH, while Taxus growth was enhanced in 1983 at the higher pH levels (4.7-5.9). Foliar nutrient concentration trends were similar among the 4 crops.

(915) Rathier, T. M. (1984). Various sulfur sources differ in their effects on media pH levels. American Nurseryman 159(5): 39-40, 42, 44.
Two-year-old rhododendrons, cv. Nova Zembla, were potted in a medium comprising equal parts of peat, manure compost and perlite (medium A), and 3-year-old rhododendrons, cv. Roseum Roseum, were potted in a 2:1:1 mixture of softwood bark, peat and sand (medium B). In January, sulphur at 5.2 g/6-quart container

(1500 lb/acre) was applied as ferrous sulphate, or as wettable, granular or flowable formulations, the first 3 as top dressings and the last as a drench. At the end of May and in early July half of each treatment received a slow-release fertilizer (Scotts 31-5-6) at 1.5 g N/container and the effects on pH of the media were assessed at intervals up to 248 days. The pH of medium A (originally about 6.6) was reduced to the range considered desirable for rhododendrons (4.5-5.4) by all S treatments, but with medium B (about 6.5) only the wettable and flowable formulations were sufficiently effective. Fertilization had little effect on pH. Plant appearance and growth after one season in each medium were little affected by S source, compared with controls, but fertilized plants were superior.

(916) Whitcomb, C. E. (1987). Chapter 28. Solving the iron chlorosis problem. Establishment and Maintenance of Landscape Plants. Stillwater, OK, Lacebark Inc., Publications and Research: 497 - 514.

(917) Remon, J., T. Goodale, et al. (1977). Effects of sulfur on reducing the pH [hydrogen-ion concentration] of an alkaline soil [Nursery plants]. Oklahoma Agricultural Experimental Station, Research Report **760**: 18 - 20.

(918) Messenger, S. (1984). Treatment of chlorotic oaks and red maples by soil acidification. Journal of Arboriculture **10**(4): 122-128.
Soils beneath the crowns of chlorotic and healthy pin and white oaks [Quercus palustris and Q. alba] and red maples [Acer rubrum] were sampled to a depth of at least 3 ft and leaf samples collected for nutrient analysis. Soil pH was significantly higher under chlorotic trees to a depth of 18-22 inches. Nutrient imbalances were found in the leaves of chlorotic trees including high P, K and Mg and low Mn, Fe, Cu and Zn, depending on species and season. Chlorotic trees were given a variety of acid treatments from 1978 onwards, including foliar sprays with Hi-Acid, a complete fertilizer with added Fe, Mn, Zn and Cu and soil treatments (Hi-Acid, sulphuric acid, granular S, and Al, Cu, Mn and ammonium sulphates) with or without nutrient or mulch additions. Soil pH was reduced most rapidly by 10% sulphuric acid, falling from just under pH 8.0 to pH 6.2 in 3 wk; pH remained below 6.2 for at least 14 months. Sulphuric acid was also most effective in reducing chlorosis which decreased or disappeared between 3 months and 2 yr of treatment.

(919) Whitcomb, C. E. (1986). Solving the iron chlorosis problem. Journal of Arboriculture **12**(2): 44-48.
Pin oaks [Quercus palustris] in landscape plantings in USA often show signs of chlorosis. Soil applications of granular sulphur were effective in reducing or eliminating the chlorosis of pin oaks growing on an alkaline heavy clay soil in Oklahoma. A single application in June 1975 of S at 10 lb/100 ft2 increased the availability of Fe and Mn after 3-6 months. Soil samples in May 1985 showed that the availability of these elements was still greater in soil treated with S than in untreated soil.

(920) Korcak, R. F. (1987). Iron deficiency chlorosis. Horticultural Reviews. J. Janick. New York, Van Nostrand Reinhold Co. **9**: 133 - 186.

(921) Shock, C. C. (1996). Granular matrix sensors, Oregon State University. **1996**.

(922) Marthaler, H. P., W. Vogelsanger, et al. (1983). A pressure transducer for field tensiometers. Soil Science Society of America Journal **47**(3): 624-627.
This paper describes a pressure transducer system for field-installed tensiometers. The system consists of a pressure transducer with attached syringe needle and digital read-out. The needle is inserted through the septum stopper which closes the upper end of the tensiometer. The pressure in the air below the septum stopper, in equilibrium with the water pressure, is read on the digital read-out, which is calibrated in millibars. Upon withdrawal of the needle from the tensiometer, the septum stopper seals the tensiometer. The pressure transducer system is easy to use and requires little maintenance. Possible errors with the measurement system are discussed.

(923) Blackwell, P. S. and M. J. Elsworth (1980). A system for automatically measuring and recording soil water potential and rainfall. Agricultural Water Management **3**(2): 135-141.
A system is described for the automatic simultaneous measurement and recording of soil water potential and rainfall. Tensiometers with fluid scanning switches and pressure transducers measure soil water potential. The fluid switch system also measures water depth in a series of bottles collecting rain from a catching trough. A versatile electronic system controls the rate and frequency of scanning by the fluid swich; a data logger collects the tensiometer and rain gauge signals and calibration values for calculating hydraulic potential and depths of collected rain. The system was tested for accuracy, reliability and response to rapid changes of water potential and rainfall.

(924) Murphy, T. A. (1996). Sensing the elements: Moisture sensors and weather stations. **1996**.

(925) Wilkerson, D. C. and M. A. Arnold (1996). Nursery and floral Innovations in irrigation. **1996**.

(926) Lamm, F. (1995). Improvements in irrigation efficiency.

(927) Roberts, J. C. and S. W. Styles (199?). Drip irrigation technology: a resource management tool for farmers.

(928) Eldredge, E. P., C. C. Shock, et al. (1993). Calibration of granular matrix sensors for irrigation management. Agron J **85**(6): 1228-1232.
Granular matrix sensors (GMS) represent an alternative technology for measuring soil water to schedule irrigation.When GMS were tested by drying them to measure changes in electrical resistance with decreasing water content, their resistance response to drying in an oven was similar ($t = -0.87$, 134 df) to that for drying in a field soil, with a response curve that suggested GMS could be used to measure soil water potential (psi). Granular matrix sensor meter readings were compared with tensiometer, neutron probe, and gravimetric measurements of soil water in the root zone of potato (Solanum tuberosum) grown in silt loam soil in Oregon, USA. Measurements with GMS were closely related to soil water potential measurements and to soil water measured gravimetrically or by neutron probe. It is concluded that GMS can substitute for tensiometers in irrigation management when irrigation criteria based on soil water potential have been established.

(929) Parchomchuk, P., C. S. Tan, et al. (1997). Practical use of time domain reflectrometry for monitoring soil water content in microirrigated orchards. Measuring soil and plant water status to indicate irrigation needs in horticultural crops **7**(1): 17-22.
In trials at the Summerland Research Station, British Columbia, Canada, time domain reflectometry (TDR) was found to be a rapid and effective method of measuring soil water content (SWC) in microirrigated orchards, particularly in applications where many sites are monitored frequently. With simple modifications to commercially available systems, it was possible to measure up to

100 sites per hour. TDR SWC measurements were successfully applied for scheduling irrigation and for in situ determination of SWC characteristics. The determination of plant water use from changes in SWC of microirrigated trees, however, required that a sufficient number of probes be used to detect the spatial distribution of water within the root zone. Due to water redistribution in the soil following irrigation, measurements made near drip emitters depended highly on the time after irrigation that the measurement was made. It is therefore important to be consistent in the timing of SWC measurements relative to irrigation events if the effects on SWC of different irrigation management practices are to be compared.

(930) Shackel, K. A., H. Ahmadi, et al. (1997). Plant water status as an index of irrigation need in deciduous fruit trees. Measuring soil and plant water status to indicate irrigation needs in horticultural crops 7(1): 23-29.
In 1993, a survey of midday stem water potentials in several mature plum orchards in California (chosen to include a wide range of soil conditions and irrigation system types) found that orchards may be routinely managed at some level of water stress, particularly late in the growing season, without any noticeable deleterious production effects. In an almond trial at Winters, California (trees planted in 1991 and grown for 2 years under 3 contrasting irrigation regimes), stem water potential was closely related to overall tree growth as measured by increases in trunk cross-sectional area. In a trial on pears at Ukiah (1992-94), midday stem water potential was not only related to vegetative growth, but also to fruit growth and quality. In a combined rootstock-irrigation trial on cherry cv. Bing at Winters, stem water potential was correlated with leaf stomatal conductance and rates of shoot growth, with shoot growth essentially stopping once stem water potential dropped to between -1.5 and -1.7 MPa. No rootstock effect on midday stem water potential was apparent under fully irrigated conditions, but when irrigation was reduced trees on Colt rootstock exhibited a more rapid decline in water status than those on Mahaleb. In many of these field studies, tree-to-tree differences in water status were large enough to obscure irrigation treatment effects. It was concluded that stem water potential can be used to quantify stress reliably and guide irrigation decisions on a site-specific basis.

(931) Swietlik, D. (1997). Introduction to the workshop (measuring soil and plant water status to indicate irrigation needs in horticultural crops). HortTechnology 7(1): 8.

(932) Clarke, T. R. (1997). An empirical approach for detecting crop water stress using multispectral airborne sensors. Measuring soil and plant water status to indicate irrigation needs in horticultural crops 7(1): 9-16.
Substantial errors can occur in the determination of crop water stress index (for irrigation scheduling) when the method (which uses hand-held infrared thermometers to measure leaf temperature) is applied to partial canopies where exposed, hot soil is within the sensor's field of view. To overcome this, red and near-infrared images were combined mathematically as a vegetation index, which was used to provide a crop-specific measure of vegetative cover. Coupling the vegetation index with the paired radiant surface temperature from a thermal image, a trapezoidal 2-dimensional index was empirically derived capable of detecting water stress even with a low percentage of canopy cover. Images acquired with airborne sensors over subsurface drip-irrigated muskmelon fields in Arizona demonstrated the method's ability to detect areas with clogged emitters, insufficient irrigation rate or system water leaks. Although the procedure needs to be automated for faster image processing, the approach is an advance in irrigation scheduling and water stress detection technology.

(933) Schlub, R. L. and J. W. Maine (1979). Portable recorder for the continuous monitoring of soil moisture resistance blocks. J Agric Eng Res 24(3): 319-323.
A moisture block meter using an IC amplifier and MA meter, which measures the voltage drop from an oscillator caused by the moisture block impedance, and indicates it in ohms, has been designed. The circuit design eliminates the need for manual balancing and incorporates zener diodes to ensure stable readings. Interfacing a two channel analogue recorder and switching system with the meter enables sequential automatic measurements of 12 blocks and continuous recording of 1 block.

(934) Allen, R. G. (1997). Demonstration of potential for residential water savings using a soil moisture controlled irrigation monitor, Water Management and Conservation Activity; US Bureau of Reclamation, Provo, UtaH. 1997.
This one-year conservation project demonstrated new technology for conserving irrigation water by residential users. Small electronic, soil water control systems were installed in residential sprinkler systems for the 1996 irrigation season in two Utah cities, Salt Lake City, representing a metropolitan setting, and Providence, representing a small town experiencing high growth with water supply constraints. The control systems consisted of an electrical-resistance sensor inserted into the lawn that was interfaced to an electronic control unit. The control unit was, in turn, interfaced with the particular type of irrigation control clock that was in use by the residential water user. The electronic control unit, which was placed in-line between the resident's irrigation clock and irrigation valves, automatically disrupted voltage signals sent to irrigation valves whenever the soil moisture condition of the lawn was wet and irrigation was not needed. The electronic control systems only allowed irrigations when they were needed. They also eliminated the need for users to manually reprogram irrigation clocks as irrigation water requirements changed, which has in the past proved to be a difficult endeavour even with education and information dissemination.

A total of 28 installations were made in Providence and 9 systems were installed in Salt Lake City (37 total). Of these installations, 27 produced water use data of sufficient quality and completeness to allow comparison with water use from prior years. Water use by these 27 participants was compared with 39 "controls" (i.e., residences that were not a part of the study). On average, the 27 participating residences used 10% less water during the 1996 demonstration season than did the "control" group (those not in the demonstration), when compared to water use patterns during prior years. In addition, questionnaires completed by 36 participants indicated that 26 of the 36 participants observed that their lawns were "as green" or "greener" and better watered than in previous years, even though they were "conserving" water. Utah State University managed the demonstration in a "hands off" manner so that we could demonstrate the true performance, manner of use, and conservation results when users were "on their own." In other words, USU did not visit systems during the irrigation season to "tweak" them, but relied on the users to make their own voluntary adjustments to their control units.

Twenty-eight of 36 users of the technology indicated that they were impressed by the simplicity and automation afforded by the control systems and with the zero-maintenance needs. All but two users indicated that they would continue to use the systems during 1997 and beyond, even though the demonstration study was for the 1996 year, only. As an indication of the simplicity and maintenance-free operation of the systems, no telephone calls were received by Utah State University at the start of the 1997 irrigation season, when the irrigation systems were put back into operation by the participants, indicating that no problems were encountered by the users that

were not solvable by themselves only. As an indication of the simplicity and maintenance-free operation of the systems, no telephone calls were received by Utah State University at the start of the 1997 irrigation season, when the irrigation systems were put back into operation by the participants, indicating that no problems were encountered by the users that were not solvable by themselves.

(935) McDole, R. E. and C. G. Painter (1979). Wonder products in agriculture [Soil medicines of questionable value, consumer protection]. Curr Inf Ser Idaho Univ Coop Ext Serv(510): 4.
New agricultural products appear on the market in a steady stream. Some of these products have merit and contribute to the advancement of agriculture production. Others are of questionable value. These products are seldom worthless, but they may be worth very little in relation to their cost. They are often sold by honest, enthusiastic people - farmers in some cases - who use scientific-sounding sales talks and promise unbelievable benefits based on "knowledge" which is often the product of pure fantasy. These materials are often referred to as "wonder" products or "soil medicines." They are not unlike the elixir and snake oils of the old time medicine man.

(936) Bocanegra, L. (1998). Landscaping for the millenium. American Nurseryman(May 1): 34 - 39.
Imaging and computer-aided design (CAD) software has saved landscapers both time and money - and increased sales.

(937) Altekruse, H. (1998). Show and sell. American Nurseryman(May 1): 57 - 61.
A small retail nursery in upstate New York wins consumers' attention and national recognition with its display gardens.

(938) Waterman, M. P. Agriculture research looking forward. The Growing Edge: 60 - 69.
The author discusses recent breakthroughs in breeding, genetic alteration, environmental monitoring technology and biological pest controls

(939) Grubich, L. (1998). Electronic soothsayers. Fruit Grower(March): 28.
These technological breakthroughs can help you decide when to take action against disease pressure

(940) Greenleaf, C. (1998). Down with disease - careful cultural practices are crucial to keeping crops healthy. Fruit Grower(March): 24 - 25.

(941) Anon. (1998). Repair of snow and ice damage to trees. Shelterbelt News(Spring): 1 - 2.
Excessive amounts of snow and ice can cause injury to farmstead trees and shrubs. Unfortunately, before storms occur little can be done to prevent damage. Often, however, with proper care damaged trees can be restored.

(942) Alspach, L. (1998). Killing tree stumps. Shelterbelt News(Spring): 10.
When deciduous trees are cut down, they will often resprout vigorously from the base. If complete removal of the tree is required and mechanical means are not available, it is often necessary to treat the stump chemi-cally. Herbicides applied promptly after felling will move into the root system and prevent most suckering.

(943) Canada, S. (1995). Greenhouse, sod and nursery industries, Minister of Industry.
Total sales of sod and nursery products reached 352.1 million In 1995, a 5% Increase over 1994 sales and approaching the pre-recession 1990 high of $371.6 million. Sales of nursery stock alone have reached an all time high of $291.9 million, reflecting the general. Increased interest in residential landscaping

(944) Swanson, B. T. and J. B. Calkins (1995). Effect of container size on plant growth and performance: 1993 - 1995. 1995 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 129 - 137.
A significant and generally overlooked factor concerning the growth of plants in containers is the restriction of root growth to a limited volume of growing medium. Limited water and nutrient reserves, modified medium aeration and drainage, confined expansion of the root system, and promotion of intertwined and circling roots which increase the potential for girdling are also associated with growing plants in containers. Not only do these conditions result in severely root-bound plants and subsequently poor quality or unacceptable root systems, top growth and quality may also be significantly reduced. The use of larger containers at the time of initial containerization is initially more costly because larger containers cost more and more medium, fertilizer, and growing space is required. However, these costs may be recovered through increased growth rates, improved plant quality, reduced Irrigation requirements, especially during the first year, and reduction or elimination of the need for upgrading of container size depending on the end-product sales requirements.

The objective of this preliminary experiment was to investigate plant growth and development as related to initial containerization and subsequent production in various size containers over a three year production cycle.

(945) Harris, R. W., A. T. Leiser, et al. (1972). Spacing of container-grown trees in the nursery. Journal of the American Society for Horticultural Science 97(4): 503 - 506.
Young seedlings of 4 hardwood species planted in 1-gal containers were placed in a square arrangement at spacings of 18, 25 and 35 cm. At the end of the first growing season they were transplanted to 5-gal containers at spacings of 25, 43 and 60 cm. After the second growing season (during which the trees were unstaked and only lightly pruned) the best and most economical combination of height growth and stem development was achieved by plants at the intermediate spacing (25 and 43 cm apart in the first and second seasons respectively).

(946) Begeman, J. (1997). Pulp fiction. American Nurseryman(November 1): 64 - 69.
Many of the practices used in tree installation, care and maintenance are pure fiction. Knowing the facts - and not the myths - can help nursery professionals provide effective tree care

(947) Briggs, J. and T. Whitwell (1998). The best of both worlds. American Nurseryman(March 15): 38 - 40, 42 - 43.
Recent collaborations between the nursery industry and the academic world put research results where they belong - in the growers' hands.

(948) Gainer, B. L. (1998). Walking a fine line. American Nurseryman(March 15): 64 - 69.
Plant growth regulators can control plant growth, flowering and fruiting, but many growers are vary.

(949) Barney, D. L. (1997). Buying high quality stock. American Nurseryman(June 1): 36 - 41.
Retailers and landscape professionals owe it to themselves and their customers to buy only high-quality planting stock. Here's how to help ensure the trees you purchase make the grade.

(950) Mathers, H. (1995). Progress in nursery research. HortWest(September/October): 26 - 27.

(951) Dirr, M. A. (1997). Making nursery research meaningful. Nursery Management and Production(March): 55 - 57.

(952) Wolstenholme, B. N. (1973). Propogation media for container-grown fruit trees and nursery plants. The Fruit World and Market Grower 74(12): 20 - 24.

(953) Lumis, G. P. (1976). Using wood waste compost in container production. American Nurseryman 144(9): 10-11, 58, 60.
Wood waste comprising clarifier sludge or clarifier screenings from a pulp-paper mill was mixed with ground maize cobs and poultry litter in the proportion 3:1:1 by volume and after rapid composting [analysis data given] was used as an ingredient of sand, perlite and soil/perlite mixes. Juniperus sabina, Thuja occidentalis and Euonymus fortunei were grown in these media and fertilized with MagAmp (15 lb/yard3), or N20P20K20 applied weekly at 2 lb/100 gal, and the effects on top and root growth were compared after one season. With the 2 conifers differences in growth between the various treatment combinations were slight, but the top growth of T. occidentalis was greatest in the compost/soil/perlite mix with NPK fertilizer. With E. fortunei top and root growth were markedly less in compost/sand receiving MagAmp. In another trial J. sabina was grown in compost/sand or peat/sand mixes and NPK fertilizer was applied at 2 or 3 lb/100 gal. Differences in top growth after one season were slight, but the root growth of J. sabina was better in the compost/sand mix. Data are also presented on leaf nutrient element composition.

(954) Laiche, A. J., Jr. and V. E. Nash (1986). Suitability of three forest product materials as growth media for container plants. Res Rep Miss Agric For Exp Stn 11(23): 1 - 5.

(955) Adams, J. C. and B. G. Lockaby (1987). Commercially produced superabsorbent material increases water-holding capacity of soil medium. Tree Planters' Notes 38(1): 24-25.
Four levels of a commercially available superabsorbent material (Terra-sorb, a starch-based polymer) were applied to a soil medium used in container seedling production. The superabsorbent treatments increased the water-holding capacity, which was directly related to the rate of application of the superabsorbent material (1-4 lb/yd3). After watering was stopped, tomato (cv. Pelican) seedlings in a control medium consisting of peatmoss, vermiculite and perlite (1:1:1) (no superabsorbent) died rapidly, but seedlings planted in media with the superabsorbent remained viable for a longer period of time, which increased with the concentration of superabsorbent in the medium.

(956) Canavera, D. (1978). Effects of various growing media on container-grown yellow birch. Tree Planters' Notes 29(1): 12-14.
The containerized growth of yellow birch (Betula alleghaniensis) was investigated in five commercially available media; Promix BX, peat/vermiculite (4:1), peat/perlite (4:1), Jiffy Mix-Plus, and Jiffy Mix-Plus/sand (1:1). Seedlings grew significantly larger in Jiffy Mix-Plus than in all other media, apparently due to the incorporation of a slow-release fertilizer (Magamp) in the medium; however, those grown in Jiffy Mix-Plus/sand could not be planted out successfully.

(957) Laiche, A. J., Jr. (1986). Container-plant growth media and fertility studies. Proceedings of the Annual Meeting of the Arkansas State Horticulture Society(107th): 120-128.

(958) Calkins, J. B. and B. T. Swanson (1994). Container media research - coniferous vs. hardwood woodchips/with and without sand/with and without acidified water: 1994 - 1995. 1994 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 50 - 56.

(959) Calkins, J. B. and B. T. Swanson (1994). Container media research - Coniferous vs. hardwood woodchips/with and without sand/with and without acidified water: 1993 - 1994. 1994 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 44 - 49.

(960) Calkins, J. B. and B. T. Swanson (1995). Container media research - coniferous vs. hardwood woodchips/with and without sand/with and without acidified water: 1994 - 1995. 1995 Nursery and Lanscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 74 - 80.

(961) Chong, C., R. A. Cline, et al. (1991). Growth and mineral nutrient status of containerized woody species in media amended with spent mushroom compost. Journal for the American Society of Horticulture Science 116(2): 242-247.
Eight deciduous ornamental shrubs--deutzia (Deutzia gracilis Siebold & Zucc.), dogwood (Cornus alba L. 'Argenteo-marginata'), forsythia (Forsythia X intermedia Zab. 'Lynwood Gold'), ninebark [Physocarpus opulifolius (L.) Maxim.], potentilla (Potentilla fruticosa L. 'Red Ace'), privet (Ligustrum vulgare L.), rose (Rosa L. 'John Franklin'), and weigela [Weigela florida (Bunge) A.DC. 'Variegata Nana']--were grown in trickle-irrigated containers with 100% bark (control) or with bark and 33%, 67%, and 100% (by volume) of each of three sources of spent mushroom compost (unweathered, weathered, and unweathered compost leached with water). Despite large variation in species growth response to sources and levels of compost, most grew equally well or better in the compost-amended regimes than in 100% bark and were influenced little, or not at all, by initial or prevailing salt levels in the media. Shoot and root dry weight of dogwood, forsythia, ninebark, rose, and weigela (all sources), and shoot dry weight of deutzia and potentilla (weathered source only), increased linearly or curvilinearly with increasing compost levels. The reverse relationship occurred (all sources) in shoot and root dry weight of privet and root dry weight of weigela and potentilla. Leaf nutrients (N, P, K, Ca, Mg, Fe, Mn, and Zn) tended to increase with increasing compost levels, but not all species showed this response with all nutrients. Regardless of compost source or level, all shrubs were of marketable quality when harvested, except privet, which showed leaf chlorosis in all compost-amended regimes.

(962) Banko, T. J. and M. A. Stefani (1991). Effects of container medium peat content and bed surface on plant growth during capillary irrigation. Journal of Environmental Horticulture 9(1): 33-36.
Rhododendron indicum cv. Formosa, Buxus sempervirens and B. microphylla var. koreana in 2.8-litre nursery containers were grown on capillary irrigation beds of fine mortar sand kept moist with water distributed through drip tubing. The containers were filled with a mixture of pine bark, peat and sand in ratios of 9:0:1, 8:1:1, 7:2:1, 6:3:1 or 5:4:1 (by volume). (Details of liming and fertilizer application are given). The sand bed was (1) covered with Visqueen black polyethylene, (2) treated with Surflan (oryzalin) at 3 lb a.i./acre, or (3) left untreated (control). The proportion of peat in the medium had a significant effect on plant growth; in general it increased as the proportion rose to 40%. Covering the sand beds with black polyethylene to control weeds and prevent root growth into the sand had an adverse effect on plant growth, apparently by interfering with the capillary flow of water. Spraying the sand surface with Surflan reduced weed

establishment early in the growing season, but had little effect on weeds or on growth of B. microphylla var. koreana roots into the sand 4 months after the start of the trial.

(963) Cabrera, R. I. (199?). Fundamentals of container media management: Physical properties, Rutgers University. 1997.

(964) Wolstenholme, B. N. (1973). Propagation media for container-grown fruit trees and nursery plants. Citrus Grower and Sub tropical Fruit Journal No. 477: 5, 7, 9, 11, 13, 15.
The characteristics are described of several basic media and mixes commonly used for propagation, with notes on steam sterilization, soil fumigation and soil drenches.

(965) Chong, C. and B. Hamerama (1997). Paper mill shows promise as rooting medium amendment. Landscape Trades(January): 51 - 55.

(966) Koch, C. (1995). Getting the most out of your media. HortWest(September/October): 18 - 19.

(967) Fretz, T. A. (1972). Media temperatures in nursery containers. Research Report, College of Agriculture Experiment Stations, Georgia University No. 121: 15 pp.
Daily fluctuations in soil temperatures were measured in steel and polythene nursery containers with different external colours, soil media and surface barriers. Afternoon soil temperatures in fully exposed 1-gal steel containers often exceeded 120 deg F, at which temperature root growth is restricted. The soil temperature was about 15-25 deg higher than the ambient air temperature during the hottest part of the day. Soil temperatures in green steel containers were several degrees lower than those in similar containers lined with white styrafoam or in green high density plastic containers. Temperatures were lowest in white containers, followed by silver or yellow containers. Temperature differences between the different soil media were slight. Surface barriers of clear or black polythene caused a heat build-up in the 0-1 in layer; white fibreglass or aluminium foil covers had little effect on surface soil temperatures, compared with unprotected soil. Differences in soil temperature were also measured in containers variously packed together with different degrees of exposure.

(968) Cole, J. C. and L. Newell (1996). Recycled paper influences container substrate physical properties, leachate mineral content, and growth of rose-of-Sharon and Forsythia. HortTechnology 6(1): 79-83.
Five container substrates - pine bark (PB) + peat (PT) + sand (SD) (3:1:1), PB + recycled paper (RP) + SD (3:1:1 or 2:2:1) or vermiculite (VM) + RP + SD (3:1:1 or 2:2:1) - were used to grow Hibiscus syracus [H. syriacus] cv. Double Purple and Forsythia intermedia cv. Lynwood Gold plants in 3.8-litre containers for 4.5 months. The control substrate (3 PB:1 PT:1 SD) had higher concentrations of NH4+ in leachate than the other substrates at 3 out of 4 sampling times during the growing season. Leaf number, leaf area per plant and height of H. syracus were greater and the leaf area per leaf was smaller for all substrates containing recycled paper than for substrates without recycled paper. Forsythia plants had greater stem and root DWs and were taller in substrates without recycled paper.

(969) Aiello, A. S. and W. R. Graves (1997). Container medium and nitrogen form affect production of Amur maackia (Maackia amurensis Rupr. & Maxim.). HortScience 32(7): 1200-1203.
Amur maackia (Maackia amurensis Rupr. & Maxim.) has potential as a more widely grown nursery crop, but little information is available on effects of media and nutrition on growth of containerized plants. We compared growth of seedlings in five media and determined growth responses to two fertility regimes. After 35 days, total dry mass of plants grown in 1 perlite: 1 vermiculite (by volume) or in 5 sphagnum peat: 3 perlite: 2 soil was 3.2 times the dry mass of plants grown in three soilless media that contained composted bark; and after 70 days, growth was greater in the medium with soil than in 1 perlite: 1 vermiculite. Plants grown in solution culture with N at 0.75 mM had 1.8 times the dry mass of those provided N at 3.75mM. Form of N in solution did not affect dry mass, but N content of leaves of plants grown with greater than or equal to 50% NH4(+) was 1.3 times as great as that of plants provided only NO3(-). Plants in containers attained maximal dry mass when fertilized with solutions containing N at 10.8 mM from NO3(-), NH4(+), and urea or N at 7.5 mM with equal amounts of NO3(-) and NH4(+). None of the soilless media used consistently evoked growth similar to growth of plants in the soil-based medium.

(970) Whitcomb, C. E. (1989 (revised)). Media porosity determination. Plant production in containers. Stillwater, Oklahoma, Lacebark Inc.: 94 - 95.

(971) Weidensaul, T. C. and J. R. McClenahen (1977). Influences of rooting media on containerized tree growth. Ohio Report on Research and Development 62(6): 83-86.
Seeds of 5 tree species, used in landscaping, were germinated in tubes (conifers) or boxes (hardwood spp.) containing 6 media. Half the plots were inoculated with a mixture of Pythium ultimum and P. irregulare which cause seedling damping-off. With the conifers, survival of Douglas fir [Abies grandis] seedlings in non-inoculated plots was poorer than that for white pine [Pinus monticola] or blue spruce [Picea pungens] after 57 days. Douglas fir was also more susceptible than other conifers to damping-off. The hardwoods (yellow-poplar [Liriodendron tulipifera] and white ash [Fraxinus americana]) were virtually unaffected by the fungal inoculum. Seedling growth differed considerably between the media. For conifers, a 50:50 mixture of peat and vermiculite was best for height and overall size, followed by vermiculite only. For yellow-poplar, shoot growth was best in vermiculite alone or + composted bark, whereas white ash grew tallest in 50:50 vermiculite + bark or 70:15:15 bark + peat + sand. The shoot-root ratio for the conifers did not differ between media. For white ash, vermiculite + bark produced the ideal minimum ratio (around 1), whereas bark alone or + peat + sand produced the most satisfactory ratios and vermiculite alone the poorest ratio for yellow-poplar.

(972) Gouin, F. R. (1994). Utilizing compost in the landscape and nursery. Recycling and resource conservation: a reference guide for the nursery and landscape industries. C. W. Heuser and P. E. Heuser. Harrisburg, PA, Pennsylvania Nurserymen's Association, Inc.: 137 - 145.

(973) Threadgill, C. C., C. E. Whitcomb, et al. (1985). Effects of propagation container dimensions, and media on the growth of 4 nursery crops. Journal of Environmental Horticulture 3(3): 126-131.
Four woody nursery crops were propagated in 3 media in containers with 3 depths and 3 diameters. A container, 7.0 cm (2.8 in) depth and 5.6 cm (2.2 in) diameter provided the best plant performance both during propagation and production. Volume trend analysis suggests that depth and diameter, not just increasing volume, influence plant response. Performance during propagation was best in peat and perlite, followed by peat and vermiculite and 100% peat. However, subsequent plant growth during the growing season was best when the rooting medium was 100% peat.

(974) Schnelle, M. A. and J. C. Henderson (1991). Containers and media for the nursery. Oklahoma State University Extension Facts Cooperative Extension Service(6706): 4.

(975) Anon. Importance of aeration in container media. Abbotsford, BC, British Columbia Ministry of Agriculture, Fisheries and Food, Abbotsford Agriculture Centre: 4.

(976) Sundquist, N. (1998). Lessons in leaching. American Nurseryman 187(8): 39 - 40, 42 - 47.
A research study shows that environmentally friendly container media with low nitrate-leaching levels can be produced with either natural or synthetic slow-release fertilizers

(977) Struve, D. K. and E. L. McCoy (1996). Physical and chemical properties of media suitable for containerized bare root whip production. Journal of Environmental Horticulture 14(3): 137-141.
Moisture retention characteristics, pH, cation exchange capacity (CEC) and bulk density of media suitable for containerized bare root whip production and the effects of these media on red oak (Quercus rubra) and blackgum (Nyssa sylvatica) growth were studied. Media tested were 3:1:1, 2:1:2 and 2:2:1 (by volume) sand:composted municipal sewage sludge [Comil]:Isolite or zeolite. A similar series of media were prepared by substituting rice hulls for sand. Similar physical properties were determined for 3 media components: rice hulls, Comil and pine bark. Rice hulls and Comil had high water retention at container capacity (70.1 and 85.4%, respectively). Hence, substituting rice hulls for sand increased media water retention at container capacity and total plant available water. Media pH ranged from 4.9 (rice hulls:Comil:zeolite, 2:1:2 or 2:2:1) to 6.3 (sand:Comil:zeolite, 3:1:1). Rice hulls and Comil had bulk densities similar to pine bark (0.30 and 0.32 vs. 0.35 g/cm3, respectively); hence, the bulk density of the medium was lower when rice hulls were substituted for sand. The cation-exchange capacity of rice-hull-based media was higher than that of sand-based media. There were no differences in red oak height increases in the different media; height increase averaged 72 cm. Blackgum height was greatest (138 cm) in 2:2:1 rice hull:Comil:zeolite medium. The results demonstrate that rice hulls could be substituted for sand without reducing height increase of either species. When grown in the different bare root media, red oak and blackgum seedlings could be bare rooted by hand shaking. The root systems of both species were fibrous with many roots with intact root tips.

(978) Anon. (1997). Nutrient Management - the key to growing healthy nursery crops: Media pH, Cornell Cooperative Extension, Dept. of Floriculture and Ornamental Horticulture, Cornell University. 1998.
pH is a measure of acidity or alkalinity on a scale of 0 to 14, with 7 being neutral. The pH of the media affects many elements, including nutrient availability, plant nutrient uptake, and microorganism activity. Because media pH affects many factors, it is important to maintain proper pH throughout the growing season.

Considering the complexity of factors involved, the recommended pH for container media is between 5.5 and 6.5. Ericaceous crops usually require a slightly more acidic media environment; however, do not allow the pH to fall below the value of 4.5 for members of this plant family.

Regular media pH testing will allow you to make informed decisions if media pH adjustment is necessary. Test each media component individually and test samples of the blended product to make sure unexpected pH shifts do not occur.

(979) Appleton, B. L. (1997). What's new in growing, harvesting, transplanting. Nursery Management and Production(January): 67 - 68.

(980) Hamill, A. S., R. E. C. Layne, et al. (1975). Weed control in a fruit tree nursery with herbicide-impregnated string. HortScience 10(6): 587-588.
String impregnated with simazine, atrazine and diuron (6.6%, 2.2% and 2.2% by weight, respectively) controlled weeds in rows of 8 month old peach and apricot seedling nursery stock. A single strand of herbicide-impregnated string placed on the soil surface next to the seedlings controlled all weed growth in a band 30.5 cm wide for 12 months. Placement of the string at various heights above the soil surface gave less satisfactory weed control and injured young peach and apricot leaves with which it came in contact. A wheat bioassay of the nursery soil after seedling removal indicated no phytotoxic residues. Chemical analysis of the string at the end of the experiment showed that 88% of the herbicide was released giving concns. of simazine, atrazine and diuron of 4.05, 1.35 and 1.35 kg/ha, respectively, provided that the string was on the soil surface. From summary.

(981) Pellett, H. M. and J. V. Carter (1981). Effect of nutritional factors on cold hardiness of plants. Horticultural Reviews 3: 144 - 171.
A review and discussion on the evaluation of research relating nutrition to plant cold hardiness, the relationship of nutrition to the mode of action of the cold acclimatization process, the influence of nutrient levels on different types of cold injury, and the relationship of nutrition to cold hardiness of specific temperate woody and herbaceous plants and sub-tropical plants.

(982) Lindstrom, A. and E. Stattin (1994). Root freezing tolerance and vitality of Norway spruce and Scots pine seedlings; influence of storage duration, storage temperature, and prestorage root freezing. CANADIAN JOURNAL OF FOREST RESEARCH 24(12): 2477-2484.
This study investigated the effect of different cold storage conditions on (i) root freezing of Norway spruce (Picea abies) and Scots pine (Pinus sylvestris), and (ii) the vitality of seedlings that suffered freezing injury to roots prior to storage. Container-grown 1-yr-old seedlings were stored from the end of October to April in three environments with different root temperatures: outdoor storage (-0.5 to 11.0°C), cool storage (0.7 to 3.7°C), or frozen storage (-5.0 to -3.8°C). Root freezing tolerance was determined prior to storage in October and during storage in January and March. Minimum root freezing tolerance for both species occurred in January, when >50% of spruce and pine seedlings survived 2 h exposure to -25 and -20°C, respectively. At this time, roots of frozen-stored spruce were significantly more freezing tolerant than outdoor-stored seedlings, whereas storage environment had no significant effect on pine. Freezing tolerance in roots of both species decreased from January to March in all test environments but to a lesser extent at the subzero temperatures in the frozen storage. Root freezing to -10, -15, or -20°C in late October before storage resulted in reduced post-storage survival of seedlings in April. Pine was more adversely affected (0-13% survival) than spruce (0-85% survival). Freezing of roots prior to storage caused the lowest survival with frozen storage.

(983) Swanson, B. T. and J. B. Calkins (1995). Overwintering of container grown Syringa meyeri plants: 1994 - 1995. 1995 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 174 - 175.

(984) Reich, L. (1978). Winter care of containerized plants

[Deciduous fruit trees and shrubs]. North American Pomona 12(2): 93 - 94.

(985) Bilderback, T. E., R. E. Bir, et al. (1996). Low investment propagation/winter protection structure, Dept. of Horticultural Science, North Carolina Cooperative Extension Service, North Carolina State University. 1996.

(986) Burris, K. (1996). Surviving the winter: a look at plant dormancy. The Digger(October): 15 - 16.

(987) Anon. (1996). ???? Nursery Management and Production(November): 30 - 33.

(988) Fitzpatrick, G., L. Griffith, et al. (1986). Evaluation of antitranspirants for cold protection in the nursery. Proceedings of the Florida State Horticultural Society publ. 1987: 99: 258-260.
Three commercial antitranspirants, Envy, Folicote and Vapor Gard, were evaluated at various concentrations on 7 container-grown ornamental species: Dracaena marginata, Cocos nucifera, Ficus benjamina, Brassaia actinophylla [Schefflera actinophylla], Ixora chinensis, Jasminum volubile and Chrysalidocarpus lutescens. All plants were in 10-inch-diameter containers in nursery plots in the open. The compounds were applied on 18 Dec. 1985 and, for some plants, again on 27 Jan. 1986, and their efficacy was evaluated on 17 Jan. and 20 Feb. by assessing plants visually for salable quality. On 2 dates, 26 Dec. and 28 Jan., the minimum air temperature approached but did not reach freezing point; daily minimum and maximum temperatures are shown for Dec.-Feb. For C. lutescens, C. nucifera, B. actinophylla and J. volubile no significant differences in quality grading could be attributed to the spray treatments. Some differences, but not consistent ones, were observed for the other species with regard to Vapor Gard and Folicote at certain concentrations. Further research into possible phytotoxic effects is advised before recommending antitranspirants for cold protection.

(989) Barney, D. L. (1991). Winter protection for containerized nursery stock. Curr Inf Ser Coop Ext Serv Univ Idaho(892): 4.

(990) Larsen, F. E. and S. S. Higgins (1998). Abscisic acid as a potential deciduous fruit tree nursery stock defoliant. HortTechnology 8(1): 47-51.
Abscisic acid (ABA) was tested as a defoliant of nursery trees of Bartlett pears and apples (cultivars Imperial Gala, Gibson Golden Delicious, Scarlet Spur Delicious, Law Red Rome, Granny Smith, Braeburn and Red Fuji). ABA was sprayed once or twice, with 1 intervening week, at 500, 1000 or 2000 ppm. Percentage defoliation was assessed at 1-week intervals for 4 weeks. For all cultivars, 2 applications of ABA at 2000 ppm ranked among the most effective treatments for rapid defoliation; this treatment led to at least 95% defoliation for all cultivars. For many cultivars, however, other treatments caused similar defoliation percentages by digging time. All tested cultivars were effectively defoliated (>80%) by two 1000-ppm applications ABA or one 2000-ppm application. One or two 500-ppm applications effectively defoliated pears, Gibson Golden Delicious and Law Red Rome. Nursery managers, therefore, need to consider a range of ABA concentrations and alternative application protocols to obtain optimum benefit from ABA.

(991) Larsen, F. E. and G. D. Lowell (1977). Tree fruit nursery stock defoliation with harvest aide chemical and surfactant mixtures. HortScience 12(6): 580-582.
Harvade (2, 3 dihydro-5,6-dimethyl-1, 4-dithiin 1, 1, 4, 4 tetraxide) + Dupont-WK (D-WK) surfactant (dodecyl ether of polyethylene glycol) stimulated leaf abscission on apple, pear, cherry and peach nursery stock. Species and cultivars varied considerably in sensitivity to the mixture, but 1 to 3 applications of 100 to 200 p.p.m. Harvade + 0.5 to 1.0% D-WK at weekly intervals were generally effective without significant damage. Higher rates often caused excessive damage, particularly if applied more than twice.

(992) Swanson, B. T. and J. B. Calkins (1995). Early fall defoliation of container stock: 1992 - 1995. 1995 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 170 - 173.

(993) Cummins, J. N. and P. Fiorino (1969). Pre-harvest defoliation of apple nursery stock using Ethrel. HortScience 4(4): 339 - 341.
Two-year-old apple trees growing in the nursery row were effectively defoliated by sprays of Ethrel at concentrations of 2000, 3750, and 5000 ppm. Retarded shoot growth and polarity reversal indicated that a 5000 ppm concentration was supraoptimal.

The 2000 ppm concentration somewhat delayed early spring growth, but not unacceptably so. Using this or a slightly lower level appears quite promising as a commercial practice. Development of visible root germs was greater on Ethrel treated plants.

(994) Swanson, B. T. and J. B. Calkins (1994). Early fall defoliation of container nursery stock: 1992 - 1995. 1994 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 93 - 97.

(995) Gouin, F. R. (1980). Overwintering container-grown ornamentals under thermo-blankets with and without clear, white or black polyethylene. HortScience 15(4): 491-492.
Early spring flowering of Forsythia X intermedia and growth of Cydonia sinensis could be prevented by overwintering container grown plants under 0.63 cm thick microfoam thermo-blankets covered with black, white or clear polyethylene, or a polyethylene foam blanket. Although covering microfoam with black polyethylene could extend its useful life and suppress the growth of winter weeds, it appeared damaging to Cupressocyparis leylandii and Prunus laurocerasus. Ilex crenata, Viburnum rhytidophyllum and Euonymus alatus cv. Compacta responded equally well to all treatments. Thermo-blankets protected the roots from minimum killing temperatures but the highest maximum temperatures were measured under polyethylene foam and microfoam covered with clear or woven clear polyethylene.

(996) Still, S. M. Defoliation of nursery stock for early harvest. .
Before lifting 2-year-old Golden Delicious, Winesap and Hopa trees and 1-year-old apple and pear seedlings were treated, on 1 October, with various combinations of ethephon at 250-1500 p.p.m., endothal at 250-1000 p.p.m. and cycloheximide at 5 or 10 p.p.m. Defoliation and damage were assessed 2 weeks later. The low (250 p.p.m.) rates of ethephon and endothal were particularly effective; defoliation was not complete without endothal even at higher ethephon rates. The synergistic effect between ethephon and endothal is discussed. Heavy damage to Golden Delicious and Winesap trees and to pear seedlings was attributed to an unseasonably warm October.

(997) Anon. (1997). Rushing against mother nature. Nursery Management and Production(January): 54.

(998) Thornton, L. (1997). Advanced postharvest techniques in the Pacific Northwest. Nursery Management and Production(January): 50 - 52, 55 - 56.

(999) Pellett, N. and D. Heleba (1994). Comparison of chopped newspaper with microfoam for winter protection of container-grown nursery stock. HortTechnology 4(1): 55-57.
Container-grown Juniperus horizontalis cv. Prince of Wales, Physostegia virginiana cv. Crown of Snow, Gaillardia grandiflora cv. Goblin and Daphne burkwoodii cv. Carol Mackie plants were covered in blocks on 21 Nov. 1991 and the covers removed on 10 Apr. 1992. For the cover treatments, a double layer of 0.64-cm-thick microfoam was compared with chopped newspaper at 3.5 or 7.0 kg/m2 enclosed in white polyethylene sheeting or at 3.5 kg/m2 enclosed in nylon netting. During Jan. and Feb., ambient temperatures sometimes fell to -18°C and lower. All coverings increased the temperature of the container medium during these periods and greatly increased the percentage of living plants (recorded in May) compared with uncovered controls. In D. burkwoodii, net-enclosed newspaper resulted in far fewer plants having vigorous shoot growth (3 or more shoots longer than 2 cm) in May than the other treatments (9 vs. 51-70%, respectively). The percentage of G. grandiflora plants with vigorous shoot growth was higher with the microfoam covering than with the newspaper treatments (98 vs. 48-70%, respectively), but all coverings provided equally good protection for J. horizontalis and P. virginiana.

(1000) Regan, R. P., R. L. Ticknor, et al. Alternative covering materials for winter protection of container-grown nursery stock. Proc Natl Plant Congr 20: 209-213.
Nine winter protection cover treatments (Agronet, Tufbell 4000N, Agryl P17, Lutradur, Reemay 2014, Vispore 5042, white polyethylene house, Microfoam + white polyethylene, and an uncovered check) were applied to 5 (Japanese holly, euonylnus, rhododendron, heather, and cotoneaster) container-grown ornamentals. The Pacific Northwest experienced a mild winter and no winter damage was observed in the uncovered check. Cover treatments increased the mean daily plant canopy air temperature by 2.0 to 5.5OF, while the mean daily media maximum and minimum temperatures were increased by 0.5 to 2.0OF and 1.0 to 3.5OF, respectively. Four treatments (Microfoam + white polyethylene, Lutradur, Reemay 2014, and white polyethylene house) reduced the cumulative number of hours of canopy exposure to temperatures below 30OF by 72 percent or more, and reduced the amount of red pigmentation in euonymus.

(1001) Sydnor, T. D., J. A. Chatfield, et al. (1995). Winter injury in woody ornamental plants in Ohio: the winter of 1993-1994. Special Circular Ohio Agricultural Research and Development Center(142): 18-23.

(1002) Fuchigami, L. H. (1977). Ethephon-induced defoliation and delay of spring growth in Cornus stolonifera Michx. Journal of the American Society for Horticultural Science 102(4): 452-454.
The effectiveness of ethephon at 250-2000 p.p.m. in inducing defoliation and in delaying spring bud growth of red-osier dogwood was related to the time of application. Plants treated before they matured were not defoliated. Mature plants were defoliated and effectiveness increased progressively at subsequent ethephon treatment dates. Ethephon treatments applied on September 29, October 6 and 13, delayed spring bud-break by 7, 5 and 3 days, respectively. Hand defoliation on the same dates induced identical delays in spring growth.

(1003) Kelley, J. D. (1972). Nitrogen and potassium rate effects on growth, leaf nitrogen and winter hardiness of Pyracantha coccinea 'Lalandi' and Ilex crenata 'Rotundifolia'. Journal of the American Society for Horticultural Science 97(4): 446-448.
P. coccinea and I. crenata grown in 1-gal containers for 1 season and fertilized with 1.32 or 1.98 lb of NH4NO3/100 gal of water made the best growth as determined by the number of laterals and total growth per plant. Higher rates of N (up to 3.3 lb) produced little or no additional growth. The optimum concentration of leaf N was about 2.32% for P. coccinea and 2.65% for I. crenata. None of the 6 rates of K compared (0-2.2 lb K2SO4/100 gal) had any significant effect on growth or leaf N levels. Interactions between N and K were not significant. High correlation coefficients (r = .95) were found between leaf N and total growth per plant for both species. N concentrations in the leaves of P. coccinea and the ability to overwinter, however, were negatively correlated.

(1004) Whaley, R. E. and L. J. Buse (1994). Overwintering black spruce container stock under a Styrofoam SM insulating blanket. Tree Planters' Notes 45(2): 47-52.
In northwestern Ontario, large numbers of container seedlings are overwintered either outdoors or in frozen storage. Seedlings stored outdoors are subject to severe conditions overwinter and are prone to considerable damage, whereas freezer storage is expensive and has its own associated risks. Different configurations of a rigid Styrofoam SM insulating blanket were tested as an alternative method for overwintering black spruce (Picea mariana) container stock. Third-year outplanting results showed no differences in growth or survival performance between controlled frozen and Styrofoam SM stored stock. Storing seedlings in Styroblocks under Styrofoam SM had potential cost savings over freezer storage of about $20 (Canadian) per thousand seedlings.

(1005) Bilderback, T. E. and R. E. Bir (1991). Nursery crops production manual: preparing nursery plants for winter. AG N C Agric Ext Serv N C State Univ(454): 11.
It usually requires more than one season to produce marketable woody nursery crops. Thus nursery crops must survive at least one winter before they can be sold. Successful winter survival means that the roots remain alive and the upper foliage is healthy, shows little damage, and is ready to resume growth.

Most plants produce a flush of growth in the spring, and this growth may continue throughout the season. Growth gradually slows in the fall because of cooler tempera-tures and shorter days. To grow plants more rapidly, we can extend the period of rapid growth by fertilizing, irrigating, and control-ling pests; however, plants are less tolerant of low temperatures during this time.

Several physiological requirements must be met to successfully overwinter nursery plants. To choose the appropriate winter-protection techniques, you must know how plants acquire cold hardiness and how they are damaged by cold temperatures and winter conditions.

(1006) Taylor, R. D. and M. B. Badenhop (1985). Comparative costs of overwintering container-grown nursery stock. ESO Ohio State Univ Dep Agric Econ Rural Soc(1174): 13.
Practically all plants grown in containers as well as field-grown plants harvested in the autumn for spring sales in U.S.D.A. Plant Hardiness Zones 5 and 6 suffer damage or death if not protected. Costs of overwintering plant material contribute significantly to the expense of producing nursery products in Northern Plant Hardiness Zones. Nurserymen in the Southern region have not traditionally been as concerned about overwintering plants as nurserymen in the Northern regions. However, losses due to death or damage of plants in the Southern Plant Hardiness Zones when not protected can also be considerable.

(1007) Schuett, J. and J. E. Klett (1989). Preemergent weed control in container-grown herbaceous perennials. Journal of Environmental Horticulture 7(1): 14-16.
In trials during 1986-87, Surflan (oryzalin) at 2.24-6.72 kg a.i./ha,

Ronstar (oxadiazon) at 4.48-13.44 kg and Rout (oxyfluorfen + oryzalin) at 3.36-10.08 kg were applied to container-grown Ajuga reptans [var.] atropurpurea (carpet bugle), Campanula garganica [var.] major (bellflower) and Liatris spicata (spike gayfeather) and Devrinol (napropamide) and Treflan (trifluralin) were each applied at 4.48, 8.96 and 13.44 kg to Astilbe adendsii (false spirea) and Dicentra spectabilis (bleeding heart). Weed control was acceptable with all herbicides except Surflan at 2.24 kg a.i. which did not control Capsella bursa-pastoris. Surflan at either 4.48 or 6.72 kg a.i. resulted in phytotoxicity of carpet bugle, while the 6.72 kg rate significantly reduced plant growth.

(1008) Staats, D., D. Hillock, et al. (1998). Weed control and phytotoxicity of preemergence herbicides applied to container-grown herbaceous plants. HortTechnology 8(3): 325-328.
Five preemergence herbicides were applied to 7 herbaceous perennials to evaluate weed control and phytotoxicity. The species used during 1992 were Rudbeckia fulgida cv. Goldstrum, Digitalis purpurea cv. Excelsior, Leucanthemum X superbum cv. Alaska, Stokesia laevis cv. Blue Danube and Geum quellyon cv. Mrs. Bradshaw. The species used in 1993 were Achillea tomentosa and Thymus pseudolanuginosus. The same mixture of weed species (Setaria glauca [S. pumila], Echinochloa crus-galli, Poa annua, Capsella bursa-pastoris, Senecio vulgaris and Amaranthus retroflexus) was used both years. The herbicides and rates were napropamide (Devrinol 10G) at 4 and 8 lb a.i./acre; metolachlor (Pennant 5G) at 4 and 8 lb a.i./acre; oxyfluorfen + oryzalin (Rout 3G) at 3 and 12 lb a.i./acre; trifluralin (Treflan 5G) at 4 and 8 lb a.i./acre; and oxadiazon (Ronstar 2G) at 4 and 8 lb a.i./acre. Plants were grown in no. 1 containers and weed seeds were sown onto the substrate surface. Two control treatments, no herbicides but with weeds (weedy control), and no weeds or herbicides (weed-free control) also were evaluated. Weed control was effective and similar for all herbicides tested. Napropamide at 8 lb a.i./acre caused stunting in D. purpurea (20-45% less growth than the weed-free control). Oxyfluorfen + oryzalin at 12 lb a.i./acre caused severe phytotoxicity (_80-95% of plant injured) and stunted the growth (70-80% less growth, sometimes plant death) of A. tomentosa. T. pseudolanuginosus was stunted by all herbicides when applied at the recommended rates (42-97% less growth than controls) except for oxadiazon and oxyfluorfen + oryzalin. T. pseudolanuginosus appeared to be more susceptible to phytotoxicity than other species due to its less-vigorous growth habit and shallow, adventitious roots that were in contact with the herbicide.

(1009) Anon. (1996). ???? Nursery Management and Production(August): 30 - 32, 34 - 35, 37.

(1010) Garner, J. M., G. J. Keever, et al. (1998). Sequential BA applications enhance offset formation in Hosta. HortScience 33(4): 707-709.
A study conducted in 1995 and repeated in 1996 determined the effects of repeated benzyladenine (BA) applications and subsequent repeated removals on yields of offsets in Hosta stock plants. Cultivars Francee and Francis Williams received 0, 1, 2, 3 or 4 foliar applications of 3000 mg BA/litre. Plants receiving multiple applications were retreated at 30-day intervals following offset removal from all plants. A single BA application stimulated offset formation in both cultivars in both years, but repeated applications were necessary for a continued response following offset removal. Total offset yield increased linearly as the number of BA applications increased. At 120 days after the first treatment in 1995, Francee plants receiving 4 applications had produced an average of 22 offsets, Francis Williams plants produced 18 offsets, and control plants produced 9.8 and 0 offsets for the 2 cultivars, respectively. For 1996 the data were 31.2 offsets for Francee and 22.4 offsets for Francis Williams, with 6.8 and 2.6 offsets for controls of each cultivar, respectively. Offset stage of development, as indicated by leaf number, and growth index were not affected by BA treatment. No phytotoxicity was observed, and plant appearance was enhanced due to the outgrowth of BA-stimulated lateral buds.

(1011) Konjoian, P. S. (199?). The use of ethrel to chemically pinch and time flowering of horticultural crops. Canadian Florist, Greenhouse and Nursery: 36.

(1012) Barrett, J. (1994). The benefits of drench applications. Greenhouse Manager(December): 66 - 68.

(1013) Kelting, M., J. R. Harris, et al. (1998). Biostimulants and soil amendments affect two-year posttransplant growth of red maple and Washington hawthorn. HortScience 33(5): 819-822.
This experiment tested several types of biostimulants on post-transplant growth of Acer rubrum (red maple) and Crataegus phaenopyrum (Washington hawthorn) trees, both with and without irrigation and fertilizer applications. Soil treatments were applied at planting as: (1) control (native backfill only); (2) compost (native backfill + yard-waste compost); (3) peat (native backfill + Canadian sphagnum peat); (4) granular humate, 100 g/tree; (5) granular humate, 200 g/tree; and (6) liquid humate + a proprietary liquid mixture of humate, kelp extract, thiamine, and intermediate 'metabolites'. Irrigation regime X soil treatment interaction was significant for red maple, but soil treatments did not increase height, stem diameter, top dry mass, or root length. For Washington hawthorn, soil treatments did not increase height, stem diameter, or root length, but top dry mass in all treatments as a group, and in humate-treated trees in particular, was greater than that of controls. Roots of peat-treated trees of both species were longer than those in other treatments. Granular humate applied at 200 g/tree increased total root length more than applications of 100 g/tree in Washington hawthorn but not in red maple. N fertilizer at 14.5 g N/m2 at planting had no effect on any parameter measured for either species.

(1014) Elfving, D. C., I. Schechter, et al. (1996). Effects of root pruning and benzyladenine application on tree growth and fruit size in 'Empire' and 'McIntosh' apple. Journal of Tree Fruit Production 1(2): 1-13.
In trials during 1991-93 at Simcoe, Ontario, postblossom sprays of benzyladenine (BA; 100 mg a.i./litre), thinned developing fruits of the apple cultivars Empire and McIntosh. Fruit weight was also increased but yields/tree were reduced. Increases in shoot growth and trunk growth were also observed in some treatments. In most of the trials, root pruning reduced fruit load rather than fruit size. BA consistently increased fruit size in 1991 with a consequent improvement in fruit size grade-out. Return flowering was improved by BA in some trials and in all but one trial by root pruning. The effects of BA and root pruning were largely independent.

(1015) Swanson, B. T. and J. B. Calkins (1994). Container-growing-in-the-ground: 1994 - 1996. 1994 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 98 - 99.
Container-GrOwiflg-In-the-Ground (OGIG) is a practical alternative to growing trees and shrubs in the field or in above ground containers. OGIG production systems enable production of easily marketable, caliper sized trees and can eliminate difficulties associated with typical container growing methods such as the need for winter protection for plant roots and wind tipping of containerized trees. In addition, growing plants in containers lengthens the transplanting season and improves transplantability

F3

and transplant success, especially for tap-rooted plants. A common problem associated with CGIG production systems, however, is roots growing out into the surrounding soil through the container drainage holes.

A study initiated at the TRE Nursery in 1991 and completed in 1994 evaluated potential root control measures for preventing roots from growing out of the containers and into the surrounding soil in CGIG production systems. The objective of this new three-year study was to expand on the initial research and compare double containers, herbicide barrier systems, and a copper-based, chemical root control treatment (Spin Out) regarding their effectiveness in preventing roots from growing out of containers and into the surrounding soil.

(1016) Thornton, L. (1997). Cherry Lake Farms - growing big trees for a worldwide market. Nursery Management & Production(Jaunuary): 38 - 41.

(1017) Swanson, B. T. and J. B. Calkins (1995). Container-growing-in-the-ground: 1994 - 1996. 1995 Nursery and Landscape Projects and Programs. B. T. Swanson. St. Paul, MN, University of MN, Extension Service: 138 - 140.

(1018) Pellett, H. (183). An update on the Minnesota System of container production. American Nurseryman 157(1): 95-99.
The advantages and disadvantages of the Minnesota System [see HcA 51, 9608] are outlined. Data are presented on the stem diameters of several ornamental trees, including Acer rubrum, A. saccharum, Quercus bicolor and Tilia cordata, grown in 20-gal containers for 12, 18 or 30 months.

(1019) Pellett, H. (1981). The Minnesota System - a new approach to tree production. American Nurseryman 153(10): 14, 38, 40, 42, 44.
The system described was developed to overcome transplanting problems of container-grown ornamental trees with taproots, as well as to avoid root circling within the containers, winter injury to the root systems and tipping over of containers in windy weather. The trees are grown in bottomless square or circular rigid polyethylene containers with sharp vertical ridges, or in polyethylene film inside woven wire fencing, and a fibreglass mat is placed underneath before putting in plastic outer containers permanently buried in the ground. These outer containers have drainage holes in the sides about 3 inches from the bottom with gravel up to that height. In a trial with several tree species, roots of Quercus rubra, Q. bicolor, Ostrya virginiana and Betula spp. grew through the fibreglass mat after one season and were effectively pruned at the level of standing water, but roots of Salix alba, var. Niobe, grew into the standing water and survived. The advantages of the system compared with balled and burlapped field production methods are summarized.

(1020) Cuny, H. (1996). Alternative production - what you need to know for growing in alternative containers. Nursery Management and Production(December): 34 - 36.

(1021) Parkerson, C. H. (1990). P & P: a new field-type nursery operation. Proceedings of the International Propagation Society 40: 417 - 419.

(1022) Ruter, J. M. (1993). Growth and landscape performance of three landscape plants produced in conventional and pot-in-pot production systems. Journal of Environmental Horticulture 11(3): 124-127.
The growth of Ilex X attenuata cv. Savannah, Lagerstroemia indica X L. fauriei cv. Natchez and Magnolia X soulangiana plants in a conventional above-ground container production system using 26-litre containers was compared with that in an in-ground 'pot-in-pot' (PIP) production system. In the latter system, a holder pot is placed permanently in the ground and the container-grown plant is placed inside the holder pot for the growing season. Container production system had little or no effect on shoot growth after 7 months. For the container phase of the study, root DW inside the container and total root DW were higher for L.indica X L. fauriei and M. soulangiana grown in the PIP system, and the root:shoot ratio of L.indica X L. fauriei was 87% higher, compared with the conventional system. Between 16.00 and 17.00 h (1 July 1991), root-zone temperatures in the western quadrant of plants in the PIP system were 13°C lower than in above-ground containers in the conventional system. Root ratings were higher for all 3 species in the PIP system. After being transplanted in the field for several months, few differences in landscape establishment between production systems could be seen for I. attenuata and L. indica X L. fauriei. Results of these studies indicate that, for L. indica X L. fauriei, production advantages seen during the container-phase of the PIP system may not be evident after one season in the field.

(1023) Harris, J. R., A. X. Niemiera, et al. (1996). Chemically controlling root escape in pot-in-pot production of river birch and Yoshino cherry. HortTechnology 6(1): 30-34.
Three experiments were conducted to determine the feasibility of using pieces of Biobarrier, a landscape fabric with trifluralin herbicide-impregnated nodules, of various sizes, to prevent root escape of trees from the drainage holes of 56-litre containers in below-ground pot-in-pot (P&P) and above-ground Keeper Upper (KU) nursery production systems. In addition, side holes or slits were cut in some container walls to test the effect of Biobarrier on the prevention of circling roots. In experiment 1 (P&P), 5 times as many Betula nigra cv. Heritage (river birch) roots escaped through drainage holes in containers with no Biobarrier as in treatments containing Biobarrier. All Biobarrier treatments reduced root escape and resulted in commercially acceptable control. In experiment 2 (KU), the degree of root escape in river birch trees was commercially unacceptable in both controls and the Biobarrier treatment (32 nodules). In experiment 3 (P&P), control Prunus yedoensis (Yoshino cherry) trees and those in treatments with 10 nodules/pot had commercially unacceptable root escape, but treatments containing 20 and 40 nodules resulted in commercially acceptable control. Biobarrier did not limit shoot growth in any of the experiments. The results of these experiments indicate that Biobarrier did not prevent circling roots, but sheets containing at least 8 or 20 nodules of trifluralin acceptably prevented root escape from drainage holes in the pot-in-pot production of river birch and Yoshino cherry trees, respectively, in 56-litre containers.

(1024) Ruter, J. M. (1994). Growth of three species produced in a pot-in-pot production system. The International Plant Propagators' Society Combined Proceedings (Southern region) 43: 418-420.
In a study to reduce growth problems in potted plants due to exposure of the roots to temperature extremes, plants of Ilex X attenuata cv. Ashe Savannah, Lagerstroemia cv. Natchez and Magnolia X soulangiana were potted into No. 7 containers and either grown conventionally aboveground or placed in holder pots which had been sunk in the ground. The pot-in-pot (PIP) production system had little effect on the growth of M. soulangiana apart from producing more laterals. I. attenuata was unaffected. Plant height increased in Lagerstroemia but the growth index did not. In another experiment, plants from each of the previous treatments were planted in augured holes in the open ground. After several months growth the only difference for I. attenuata was in root regeneration beyond the original rootball which was 57% greater for conventional pot-grown plants than in PIP plants. The production system had no effect on Lagerstroemia.

(1025) Davis, T. (1996). 3 Plant protection ideas. Nursery Management and Production(December): 42 - 44.
Production techniques can be rigorous on your plants. Root zones are subject to both extreme high and low temperatures. Harvest and shipping can scar trees and reduce their salability. Here are three new ideas for protecting plants from heat, cold and shipping damage

(1026) Cole, J. C., R. Kjelgren, et al. (1998). In-ground fabric containers as an alternative nursery crop production system. HortTechnology 8(2): 159-163.
Nursery crops have traditionally been grown in the field and harvested as balled and burlapped or bare root plants or grown in above-ground containers. The in-ground fabric container has allowed producers to combine advantages of field production with those of container production. The effects of these containers on plant growth (both woody plants and ornamental woody plants), transplant establishment, plant chemical composition and water relations are species and site specific.

(1027) Anon. (1996). Fire Blight. Shelterbelt News(Fall).

(1028) Poppy, L. (1996). Danger to saskatoons. Shelterbelt News(Fall).

(1029) Johnson, G. R. (1997). Secret agents. American Nurseryman(August): 57 - 58, 60, 62 - 65.
Although trees and shrubs might show symptoms apparently caused by insects or disease, landscapers should know htat hte cuase of plant problems might be lesser-known villains - mechanical, chemical or physical agents

(1030) Sydnor, T. D. (1998). The response of Ohio's native and natural trees to construction activity. Landscape Plant News 9(1): 11 - 19.

(1031) Barton, S. S. (1998). Plant establishment in different soil types. Landscape Plant News 9(1): 2 - 5.

(1032) Appleton, B. L. (1995). New nursery production methods lead to tree root circling reduction or elimination. Arboricultural Journal 19(2): 161-174.
Tree roots that begin to circle during nursery production have the potential, once the trees are transplanted to the landscape, to enlarge to the point where they may girdle the stem or other roots. Girdling roots have been diagnosed as a cause of tree stress and decline due to a reduction in water and solute movement through the root-crown area. Several new nursery production techniques in the USA are described, including above-ground rigid plastic, 'low-profile', 'soil sock' and copper-coated containers, and in-ground fabric, rigid plastic and 'pot-in-pot' containers, that help to reduce or eliminate circling root formation.

(1033) Anon. (1996). Root Facts. Shelterbelt News(Fall).

(1034) Dellen, J. V. (1998). Raging hormones. American Nurseryman 187(1): 42 - 45.
Rooting hromones are designed to stimulate and accelerate root growth, and several products containing auxins have been introduced commercially. What type of hormone and what application method to use depends on what type of cutting you are treating

(1035) Proebsting, W. M. (1998). Cutting to the point. American Nurseryman 187(1): 30 - 35.
Whether you are a propagating novice or an expert, keeping in mind a few basic principles can make a difference in rooting cuttings.

(1036) Blythe, G. (1998). Cutting to success. American Nurseryman 187(6): 24 - 26, 28, 30.
Effectively and economically producing lining-out stock by means of cuttings for container or field production involves five basic processes. All nursery employees, whether they deal with cutting propagation or not, need to be trained in the importance and interrelation of these steps.

(1037) Walker, D. (1998). Growing poplar and willow from hardwood cuttings. Shelterbelt News(Spring).

(1038) Swartzell, D. (1993). How trees respond to root pruning. Arbor age 13(1): 24-25.

(1039) Richards, D. (1986). Tree growth and productivity - the role of roots. Acta Horticulturae No. 175: 27-36.
A review and discussion on tropical and subtropical fruit crops under the following headings: adverse effects of vegetative growth on production; co-ordination between root and shoot growth; possible mechanism of growth co-ordination; manipulating shoot growth by root treatments: root pruning; and root restriction.

(1040) Harris, R. W., W. B. Davis, et al. (1971). Root pruning improves nursery tree quality. American Journal of Horticulture Science 96(1): 105 - 108.
nursery productionCompared to no pruning, pruning of seedling roots of four tree species durin, transplanting from the seed flat to peat pots and of the peat-pot liners into gallon cans more than doubled the number of plants with acceptable root systems. Survival and growth were neither significantly nor adversely affected by root priming done over a range of transplanting dates.

(1041) Gilman, E. F. and T. H. Yeager (1988). Root initiation in root-pruned hardwoods. HortScience 23(4): 775.
In studies to determine the effect of root pruning on the location of regenerated roots and growth of existing unpruned laterals, one main root was pruned 150 mm from the stem of 8-month-old seedlings of Acer rubrum, Cercis canadensis, Liquidambar styraciflua, Platanus occidentalis, Quercus virginiana and Ulmus parvifolia. Control seedlings were not pruned. After 2 months, new roots were counted and cross-sectional areas of original laterals were calculated from measurements of root diam. Root pruning stimulated root regeneration in all species, but the numbers of new roots on the sample root varied significantly between species from 32 for Platanus to fewer than 10 in Quercus and Ulmus. At least 56% of the new roots originated within 25 mm of the cut. Lateral root cross-sectional area increased as a result of pruning in Platanus, Cercis and Liquidambar, but did not increase in the other species.

(1042) Whitcomb, C. E. (1987). Root pruning: pros and cons. Establishment and Maintenance of Landscape Plants. Stillwater, Oklahoma, Lacebark Publications: 161 - 169.

(1043) Ristevski, B., P. Kolecevski, et al. (1992). Pruning and regeneration of the root system on pear and apple trees. First international symposium on training and pruning of fruit trees, Shepherdstown, West Virginia, USA, 16 20 July 1991 No. 322: 305-310.
For 3 years, beginning in autumn 1985, 16-year-old Bartlett [Williams' Bon Chretien] pear trees were root pruned at a depth of 35 cm, 2.0 m from the base of the tree, on one or both sides. Root pruning on one side of the tree gave the largest yields over the 3 years (55.4 kg/tree) compared with pruning on both sides (48.1

kg/tree) and the control (46.8 kg/tree). In a similar experiment (1988-90) on mature apple trees (cultivars Red Delicious and Golden Delicious), root pruning on one side at a depth of 60-70 cm resulted in increases in yields of 20, 77 and 5% in the first, second and third year, respectively, compared with the control. Fruit quality was also markedly improved. It was concluded that trees should be root pruned on one side for 2 years and the other side in the third year.

(1044) Chauhan, S. K., V. K. Mishra, et al. (1994). Stimulation of new roots through root culturing - a review. Agricultural Reviews Karnal 15(2): 99-108.
The ability of a plant to establish often dep[illegible]e speed with which new roots emerge. Root culturing/pruning (undercutting, wrenching, lateral pruning, chemical pruning etc.) is used to improve root growth of seedlings in nurseries. The sequence of root regeneration following pruning, and factors affecting root regeneration, including aeration, photosynthates and carbohydrates, plant growth regulators and environmental factors are discussed. There is a table listing common and Latin names of plants (mainly trees) cited in the bibliographic references at the end of this paper. Harmful effects of root culturing are briefly discussed.

(1045) Struve, D. K. (1990). Root regeneration in transplanted deciduous nursery stock. HortScience 25(3): 266-270.
A discussion of root regeneration and regrowth in bare-rooted broadleaved stock transplanted when dormant and of the effects of auxin (typically IBA) on root regeneration, with emphasis on red oak (Quercus rubra).

(1046) Struve, D. K. and T. Khodus (1990). Turning copper into gold. American Nurseryman 172(4): 114-125.
A nursery production system for woody plants, developed at the Ohio State University, uses copper-treated containers and a modified schedule to reduce or avoid transplanting shock and obtain faster growth. The containers are either of plastic, coated inside with a mixture of Cu and latex paint, or of Cu-treated fibre. Cupric carbonate, copper sulphate and copper hydroxide have all proved suitable. Root elongation is inhibited at the sides of the pots and girdling and malformation are thus prevented. Plants are acclimatized gradually after removal from the greenhouse. Some results of trials with various landscaping species, including red maple [Acer rubrum] and red oak [Quercus rubra], are discussed.

(1047) Friesen, R. (1995). Tree and shrub problem diagnosis. Saskatoon, SK, University of Saskatchewan, Extension Division.

(1048) Iles, J. K. and N. H. Agnew (1995). Forcing herbaceous perennials to flower after storage outdoors under a thermoblanket. HortTechnology 5(3): 239-243.
Nine herbaceous perennial species were evaluated for use as flowering potted plants for late winter and early spring sales. Plugs were established in 14-cm (0.8-litre) round plastic containers, grown for one season and covered with a thermoblanket for winter. Five plants of each species were transferred to a 21±3°C glasshouse for forcing under natural daylengths at six 10-day intervals beginning on 1 Dec. 1993. Arabis sturii, Phlox X chattahoochee [Phlox cv. Chattahoochee], Platycodon grandiflorus cv. Sentimental Blue and Veronica cv. Sunny Border Blue flowered out of season without supplemental lighting. Armeria maritima cv. Alba and Chrysogonum virginianum also flowered; however, their floral displays were less effective. Bergenia cordifolia cv. New Hybrid did not flower and Achillea X lewisii cv. King Edward and Dianthus X allwoodii cv. War Bonnet only flowered sporadically. These last 3 species are not recommended for forcing out of season using this vernalization method.

(1049) Walker, D. (1996). Pruning trees and shrubs. Shelterbelt News(Fall): 2,3,9.
The rule of thumb to follow when pruning trees and shrubs is: "If you have no hood reason to prune, don't". Most trees and shrubs have a natural form to them and may do better and look better if left alone. Each kind of tree has its own characteristic shape or growth habit and when pruning, you should try to maintain that habit. There are times, though, when pruning must be done and proper procedures should be followed

(1050) Shoup, S., R. Reavis, et al. (1981). Effects of pruning and fertilizers on establishment of bareroot deciduous trees. Journal of Arboriculture 7(6): 155-157.
Trees of 6 species (Quercus palustris, Cercis canadensis, Pyrus calleryana, Fraxinus pennsylvanica, Prunus serrulata and Malus 'Hopa') and ht. 6-8 ft were planted in March, 1978, and 0, 15, 30 or 45% of the plant ht. removed before the spring flush. Fertilizer was applied to some plots at 4 lb nitrogen per 1000 ft2. Pruning or fertilization had no effect on survival or the initiation of growth. A similar study, but without fertilizers and using 5 species (Malus domestica, Pyrus communis, Prunus persica, Carya illinoensis and Fraxinus velutina) was started in March, 1979 and also showed that pruning had no effect on survival. Pruning in excess of 15% is not recommended because of its detrimental effect on natural form and branch development.

(1051) Lohr, V. I. and A. B. Sudkamp (1989). Pruning responses of tissue-cultured plantlets of rhododendrons. Journal of Environmental Horticulture 7(1): 23-25.
Plantlets of Rhododendron cultivars Molly Ann, Paprika Spiced and Travis L., recently rooted from tissue culture, were grown in a greenhouse in individual containers. Plants pruned by pinching, top-pruning, or root-pruning were compared with unpruned plants. Growth, as measured by shoot height, shoot dry weight, root dry weight, and stem caliper, was generally reduced by pruning. Top-pruning and pinching induced branching in all cultivars and improved stem taper (ratio of basal to upper diameter) in Paprika Spiced and Travis L., which is particularly prone to developing weak stems when produced by tissue culture.

(1052) Powell, D. (1987). What's the difference? American Nurseryman(June 15): 59 - 61.

(1053) Maas, E. F. and R. M. Adamson (1981). Aritificial media in horticulture - their formulation and fertilization. Ottawa, ON, Cummunications Branch, Agriculture Canada.

(1054) Beeson, R. C., Jr. and G. W. Knox Analysis of efficiency of overhead irrigation in container production. HortScience 26(7): 848-850.
The amount of irrigation water captured by containerized plants of Rhododendron cultivars Duc du Rohan and George L. Taber and Pittosporum tobira cv. Laura Lee was measured by sealing the surface of the containers with polyethylene sheeting and using an oven-dried sponge to absorb the water which collected. The plants were of marketable size and were spaced widely or with pots touching one another. The amount of water directed by impact or wobbler sprinklers on to the area covered by the individual containers was measured using empty pots. The % water captured by plants was inversely related to the leaf area contained in the projected cylinder over the container when containers were widely spaced and with total plant leaf area when pots were close-packed. This relationship was independent of leaf curvature (concave vs. convex). Canopy densities were less related to % water captured than were leaf areas. Irrigation application efficiencies ranged

from 37% at a close spacing to 25% at a spacing of 7.6 cm between containers. Container spacing, canopy shedding and possibly some canopy retention of water later lost by evaporation were determined to be the main factors associated with the low efficiencies. The results suggest that higher irrigation application efficiencies would be maintained only if plants were transplanted to larger containers before reaching maximum canopy size rather than spacing existing containers to achieve more room for canopy growth.

(1055) Armitage, A. M. The influence of spacing on field-grown perennial crops. HortScience 22(5): 904-907.
Achillea cv. Coronation Gold, A. millefolium cv. Rose Beauty, Physostegia virginiana, Liatris pycnostachya and Salvia leucantha were planted 30-, 60-, 90- or 120-cm apart. Data were collected for 2 or 3 years, depending on species. In all instances the number of flowering stems/plant increased but the number of stems/m2 decreased as spacing increased. Stem lengths of Coronation Gold, Rose Beauty and P. virginiana were affected significantly by spacing(short and medium stems increasing in length with wider spacing and long stems decreasing in length) whereas flower size and stem diameter remained unchanged.

(1056) Black, A. L. and J. K. Aase (1988). The use of perennial herbaceous barriers for water conservation and the protection of soils and crops. Agriculture, Ecosystems and Environment 22/23: 135 - 148.
A system of tall wheatgrass (Agropyron elongatum) barriers, which consisted of single or double rows of grass spaced at about 15-m intervals, protected the soil from wind erosion and conserved water for crop production. Windspeed at a height of 0.3 m above the soil surface was reduced over the intervals as a whole by about 45% by the grass barrier system, and potential wind erosion was reduced by 93.4% on an entire-year basis relative to open-field unprotected areas. The microclimate effects of the barriers relative to open-field environments include: (1) increased soil temperature in early spring; (2) decreased soil temperature in June due to greater crop canopy; (3) reduced soil drying rate of 0-100 mm soil depth following rainfall; and (4) increased winter wheat dry matter production, leaf area index and grain yields as a result of improved temperature-soil-water relations. The grass barrier system is an effective snow management tool which increased the probability of successful recropping with winter wheat (Triticum aestivum) from 55 to 78% with N fertilization over an 18-year period when 63 mm, or more, of the overwinter precipitation was stored in the soil. With N fertilization, winter wheat yields in the spring wheat-winter wheat-fallow rotation were _ 1360 kg/ha in 15 of 18 years or 83% of the time.

(1057) Samfield, D. M., J. M. Zajicek, et al. (1991). Rate and uniformity of herbaceous perennial seed germination and emergence as affected by priming. Journal of the American Society for Horticultural Science 116(1): 10-13.
Seeds of Coreopsis lanceolata and Echinacea purpurea (Texas wildflowers) were primed in aerated solutions of distilled water or 50 or 100 mM potassium phosphate (pH 7.0) at 16°C for 3, 6, 9 or 12 days. Coreopsis seeds primed in the 50 mM buffer germinated the most rapidly and uniformly, and, under stress conditions in the greenhouse, resulted in a faster-growing, more-uniform crop than other treatments. Seeds primed in distilled water or the 50 mM buffer germinated faster and at higher rates at suboptimal temperatures (15°-20°) in the laboratory than non-primed seeds. Priming of E. purpurea seeds for 6 or 9 days in distilled water or in the 50 mM buffer resulted in faster, more-uniform germination than other treatments. Seedling emergence under stress conditions was improved by all priming regimes, with best emergence occurring in treatments that lasted >3 days. Priming also increased germination rates of E. purpurea at suboptimal temperatures in the laboratory.

(1058) Corell, T. and A. Bing (1980). Preemergence weed control in ornamental perennial crops. Proceedings of the Northeastern Weed Science Society, 1980 34: 334-339.
A wide variety of container grown perennial plants were kept reasonably free from weeds and made normal growth when treated in the autumn or spring with simazine at 0.5 lb + oxadiazon 2 lb/acre. Oxadiazon at 2-8 lb/acre was safe to the crops. Treatment after potting in the autumn combined with re-treatment in spring controlled weeds for the entire production cycle and reduced [hand?] weeding costs by about 85%.

(1059) Durner, E. F. (1999). Winter greenhouse strawberry production using conditioned plug plants. HortScience 34(3): 615-616.
Two-to three-week-old Sweet Charlie strawberry plug plants were conditioned by subjecting to seven 9-h short days without chilling (21°C day/21°C night) followed by seven 9-h short days with chilling during the nyctaperiod (21°C/12°C night) in September 1997, then planted in a vertical hydroponic system for winter greenhouse production. Conditioned plugs produced significantly more fruits than did non-conditioned control plugs in January and February but the difference was non-significant in December, March and April. Total yield (December-April) was 367.9 g/plant in conditioned plugs and 225.5 g/plant in controls. Fruit yield increased linearly with height in the column (_40 g/plant for every 30-cm increase in column height), probably because of increasing light level. When productivity is considered on an area basis (kg/m2) and the column height effect on yield is accounted for, productivity over a 4.5-month period was 4.8 kg/m2 for controls and 7.8 kg/m2 for conditioned plugs. The results indicate that conditioned plug plants offer the potential for increasing strawberry productivity and therefore increasing the profitability of a winter greenhouse production system.

(1060) Merwin, I. A., J. A. Ray, et al. (1999). Orchard groundcover management systems affect meadow vole populations and damage to apple trees. HortScience 34(2): 271-274.
Meadow vole (Microtus pennsylvanicus) populations, feeding activity and damage to young apple (Malus domestica [M. pumila]) trees were monitored for several years in a New York orchard by direct observation, trap counts, and a feeding activity index in various groundcover management systems (GMSs). Meadow vole population density differed among GMSs, with consistently higher densities and more trees damaged in crown vetch (Coronilla varia), hay-straw mulch, and red fescue (Festuca rubra) turfgrass tree-row strips. Vole densities were high in autumn and low in spring each year. Anticoagulant rodenticides and natural predation did not adequately control voles in GMSs providing favourable habitat. Groundcover biomass per m2 was weakly correlated with vole densities in 2 of 3 years, while the percentage of soil surface covered by vegetation was not significantly correlated with vole populations. Applications of thiram fungicide in white latex paint were better than no protection, but less effective than 40 cm high plastic-mesh guards for preventing vole damage to tree trunks. A combination of late-autumn trapping, close and consistent mowing of the orchard floor, trunk protection with mesh guards, contiguous habitat for vole predators, and herbicide applications within tree rows provided effective control of meadow vole damage to trees at this orchard during 3 years without applications of rodenticide baits.

(1061) Rose, M. A., M. Rose, et al. (1999). Fertilizer concentration and moisture tension affect growth and foliar N, P and K contents of two woody ornamentals. HortScience 34(2):

246-250.
Crabapple (Malus Xzumi cv. Calocarpa) and maple (Acer Xfreemanii cv. Jeffersred) trees were grown in containers from 22 June to 3 October in Columbus, Ohio, with 3 fertilizer concentrations (50, 100 or 200 mg N/litre) and 2 levels of moisture tension in the medium (low setpoint (moist) = 5 kPa and high setpoint (dry) = 18 kPa). Whole-plant growth was enhanced more by minimizing water stress than by increasing fertilizer concentration. Shoot length and whole-plant dry weight were greater (>29% so for crabapple and >90% so for maple) in low tension treatments (low water stress) but were unaffected by fertilizer concentration. Moisture tension also had a dominant effect on dry-weight allocation to leaves, stems and roots. In contrast, foliar nutrient concentrations increased with fertilizer concentration but were affected to a lesser degree by moisture tension. Seasonal patterns in biomass allocation were little affected by treatments; the largest proportions of leaf and root biomass accumulated during summer and autumn, respectively.

(1062) Nyomora, A. M. S., P. H. Brown, et al. (1999). Rate and time of boron application increase almond productivity and tissue boron concentration. HortScience 34(2): 242-245.
Boron was applied to almond cv. Butte trees with a handgun sprayer either as Solubor ($Na_2B_8O_{13}.4H_2O$), a commercial product containing 20.5% B, in September (3 weeks postharvest), December (dormancy) or February (budbreak) at 0, 0.8 or 1.7 kg B/ha at Parlier (Fresno County, California), or as Borosol, a polyboronated commercial product containing 10% B, at 0, 0.8, 1.25, 1.7 or 2.1 kg B/ha in August, September or February at Orland (Glenn County, California). At Parlier, September application was more effective in increasing tissue B concentration, fruit set and yield than were December or February applications. The optimal rate was 0.8-1.7 kg B/ha when applied in September. At Orland, application in 1996 and 1997 increased tissue B concentration almost linearly, especially when applied in August and February. Application at the highest rate (2.1 kg B/ha) in September produced the greatest final fruit set and yield in 1996. February applications increased initial fruit set at both sites but were less effective than September applications at increasing yield. Application of B did not affect any yield variable in 1997. These results suggest that B should be applied immediately postharvest (September) for optimal effect on tissue B concentration, fruit set and yield in almond.

(1063) Al Harbi, A. R., A. M. Al Omran, et al. (1999). Efficacy of a hydrophilic polymer declines with time in greenhouse experiments. HortScience 34(2): 223-224.
The effect of a hydrophilic polymer (Broadleaf P4 R; HP) on growth of cucumber seedlings was investigated. Furthermore, the ability of HP to absorb water over a period of time was studied. Predetermined amounts of HP (0.0, 0.1, 0.2, 0.3 or 0.4%, dry-weight basis) were mixed with moderately calcareous sandy loam soil in pots. At the end of the first experiment (42 days), the growth of the seedlings was recorded, as well as the maximum soil water-holding capacity (WHC). The same pots were left for a drying period ranging from 2 to 5 months and then used for another 4 successive experiments. Soil WHC increased significantly with increasing level of HP, but decreased after each experiment. After 5 experiments, the WHC had decreased 17.3% and 27.8% where HP was added at the rate of 0.1% and 0.4%, respectively. The bulk density of soils decreased significantly with addition of HP and had increased after 5 growing experiments at each HP rate. Cucumber seedling growth was stimulated by addition of the polymer. The greatest vegetative growth, expressed as leaf area and shoot fresh and dry weights, was observed at 0.3% HP in the first and second experiments, but at 0.4% in the third and fourth.

(1064) Stover, E., M. Fargione, et al. (1999). Prebloom foliar boron, zinc, and urea applications enhance cropping of some 'Empire' and 'McIntosh' apple orchards in New York. HortScience 34(2): 210-214.
The following foliar nutrient treatments were applied prebloom to McIntosh and Empire trees at 2 sites in 1994 and 1995: (1) control; (2) B (22.8 mM) at half-inch-green; (3) Zn-EDTA (0.75 mm) at half-inch-green; (4) B and Zn-EDTA at half-inch-green; (5) B, Zn-EDTA and urea (59.4 mM) at half-inch-green; (6) B and Zn-EDTA at half-inch-green, followed by B, Zn-EDTA and urea at pink. In 1994, following a very severe winter that caused visible damage to vascular tissue, Empire at both sites cropped more heavily following all treatments that included both B and Zn; such treatments increased crop load by an average of 22% and 35% at the 2 test sites. Despite a mild winter preceding the 1995 season, prebloom nutrient treatments again increased cropping of Empire. In 1996, treatments included a control and a single foliar treatment (B + Zn-EDTA at half-inch-green followed by B, Zn-EDTA and urea at pink) on McIntosh and Empire at 7 orchard sites. Treatment enhanced cropping in McIntosh at 3 of the 7 sites, but there was no effect on Empire. Factors influencing differences in response were not apparent from this study, although a complex of factors may be involved. Data for all years indicated that prebloom nutrients did not enhance spur leaf development or fruit set; such treatments probably enhance cropping by increasing retention of flower buds that would otherwise abscise before anthesis. Where cropping was increased, mean fruit weight was not reduced at P_0.05 but fruit weight was significantly less at P_0.10 in 1995.

(1065) Iles, J. K. and N. H. Agnew (1993). Determining cold hardiness of Heuchera sanguinea Engelm. 'Chatterbox' using dormant crowns. HortScience 28(11): 1087-1088.
Dormant, intact crowns of the herbaceous perennial H. sanguinea cv. Chatterbox were placed in moist cheesecloth, wrapped in aluminium foil, and subjected to -4, -6, -8, -10, -12, -14, -16 or -18°C in a programmable freezer. Crown samples were removed after tissue temperature had stabilized at each treatment temperature, and allowed to thaw for 24 h at 2° before planting in containers and transferring to the greenhouse at 21°. Regrowth quality ratings and DM measurements after 60 days decreased linearly with temperature. No regrowth was evident from any crown exposed to _-12°. Freezing dormant plant crowns proved an efficient and reliable technique for estimating cold hardiness of this cultivar.

(1066) Frett, J. (1993). Perennials with panache. Am Nurseryman 177(3): 25-29.
Nine plants for sunne or shady sites: Solidago sphacelata 'Golden Fleece', Amsonia hybrectii, Asclepias tuberosa 'Gay Butterflies', Sedum x 'Brilliant', Tiarella cordifolia, Batisia alba var. alba, Chrysanthemum pacificum, Aruncus aethu???? (dwarf goat's beard),

(1067) Herman, R. M. (1992). Perennial favorites. Am Nurseryman 176(12): 99-102.
A look at some recent European perennial introductions: Anemone hypehensis x hybrida 'Pamina', A. x hybrida 'Honorine Hobert', A. x hybrida 'Queen Charlotte', Aster 'Lovely', Calamintha nepeta, Geranium x cantabrigiense, G. macrorrhizum, Rudbeckia nitida 'Herbstsonne', Salvia officinalis 'Berggarten'

(1068) Hanzawa, F., M. and S. Kalisz (1993). The relationship between age, size, and reproduction in Trillium grandiflorum (Liliaceae). American Journal of Botany 80(4): 405 - 410.
The relative importance of age and size as predictors of demographic parameters such as survivorship or reproductive

status is generally unknown for herbaceous perennials, due primarily to the difficulty in estimating the age of herbaceous plants. We investigated the relationship between age, size, and reproductive status in Trillium grandiflorum, a rhizomatous perennial herb in which age can be estimated. We measured the leaf area and rhizome volume and estimated the age of plants in a study population that included reproductive and nonreproductive individuals. Reproductive plants were significantly older (hivin X = 22.8 years) than nonreproductive plants (hivin X = 13.3 years). Reproductive plants also had significantly larger total leaf areas and rhizome volumes. Total leaf area, rhizome volume, and age were positively correlated in both groups. Reproduction in this population occurred once plants reached a threshold leaf area or rhizome volume. Both measures of plant size, i.e., total leaf area and rhizome volume, were better predictors of plant reproductive status than was plant age.

(1069) Smreciu, E. A., R. S. Currah, et al. (1988). Viability and germination of herbaceous perennial species native to southern Alberta grasslands. Can Field Nat 102(1): 31-38.
The viability and germination of seed lots of 41 herbaceous perennial species native to southern Alberta grasslands were examined. The practical value of tetrazolium (TTC) and x-ray photography in screening seed lots for viability was evaluated. Although a reliable, rapid test for a few taxa, TTC often gave erratic results which were inconsistent with germination percentages and/or the physical condition of excised embryos. X-rays were useful for determining the percentage of full seeds in samples of species having large seeds, but had insufficient resolving power for samples of smaller seeds. Stratification improved germination in most species of Compositae, all three species of the Scrophulariaceae, and both species of Cactaceae. Scarification improved germination in 11 of 12 species of Leguminosae, and, in combination with stratification, improved germination of Allium textile (Prairie Onion) of the Liliaceae. Seeds of species in both Ranunculaceae and Rosaceae generally germinated as well with as without pre--treatment.

(1070) Banovetz, S. J. and S. M. Scheiner (1994). Secondary seed dormancy in Coreopsis lanceolata. American Midland Naturalist 131(1): 75-83.
The physical and physiological factors that control germination in the herbaceous perennial, Coreopsis lanceolata (Asteraceae) were examined. Seeds stored in paper envelopes for 6-18 months at room temperature were tested for germination on moistened filter paper in Petri dishes. Germination percentages were greatest at 15° and 25°C and 12-h light/dark cycles. Germination percentages of imbibed seeds were not affected by previous storage at -10°. Imbibed seeds subjected to 5° entered a secondary dormancy that could not be broken by subsequent warmer temperatures, light/dark cycles or freezing temperatures. Secondary dormancy in C. lanceolata may be a mechanism for spreading the risk of recruitment.

(1071) Godoy, A. and J. C. Cole (2000). Phosphorus source affects phosphorus leaching and growth of containerized spirea. HortScience 35(7): 1249 - 1252.
Commercially propagated 'Halward'sSilver' spirea (Spiraea nipponica Maxim.) bareroot cuttings and cuttings with substrate around the roots (plugs) were transplanted into 3.8-L containers and fertilized with various P fertilizers to determine the effect of fertilizer source on P leaching and plant growth. The following fertilizer treatments were applied: 1) 100% of the recommended rate of P from controlled-release fertilizer (CRF), consisting of 22N-2.6P-10K; 2) 100% of P from triplesuperphosphate (TSP, 0N-20P-0K) with N and K provided by 22N-0P-10K CRF; and 3)50% of P from CRF, consisting of 22N-1.3P-10K, plus 50% of P from TSP (CRF/TSP). The most P leached from cuttings transplanted as plugs or bareroot and fertilized with TSP, while the least P leached from cuttings transplanted as plugs and fertilized with CRF or CRF/TSP. Plants fertilized with CRF/TSP generally had larger root dry weights than did plants fertilized with CRF or TSP. Plants fertilized with CRF had the smallest stem dry weights. Shoot-to-root (SIR) ratio was largest in plants transplanted as plugs in substrate amended with TSP, but cuttings transplanted bareroot into CRF-amended substrate had the highest SIR ratio and the lowest stem P concentration. Incorporation of CRF/TSP into the container substrate can reduce P leaching compared with incorporation of TSP, and can increase root and stem dry weights of plants transplanted as plugs compared with incorporation of CRF.

(1072) Perry, L. P. (1990). Overwintering container-grown herbaceous perennials in northern regions. Journal of Environmental Horticulture 8(3): 135-138.
In a 3-year study, survival was evaluated in 9 container-grown herbaceous perennials using various overwintering techniques. Covers were applied in Nov.-Oct. and removed at different times between 1 Apr. and 2 May. Although species reacted individually to overwintering covers, those covers with white reflective surfaces (e.g. white polyethylene film) generally provided adequate protection. Straw, non-reflective Plantfoam (plastic) or no cover usually resulted in large plant losses. Container medium temperatures were 4-7°C higher than surrounding air temperatures; a sandwich of 30 cm deep fluffed oat straw between layers of white polyethylene provided the least temperature fluctuation in the medium (3° with an ambient fluctuation of 16°) and the greatest temperature moderation (1° with ambient -16°). Uncovering plants later than the first week in Apr. occasionally resulted in plant losses.

(1073) Roh, M. S., R. H. Lawson, et al. (1996). New floral crops in the United States. Progress in new crops: Indiana: 526-535.
Achievements during the last 10 years of a cooperative programme between the USDA and industry to develop new floral crops are presented. The report describes: the acquisition of new crops from Europe (Denmark, Netherlands and Austria), Japan, Thailand, Australia, New Zealand, South America and South Africa and their evaluation as potential new floral crops; progress with the development of specialty field-grown cut flower crops, annuals and perennials, and woody plants; and the development of new technologies to shorten the total cropping time of both new and old crops.

(1074) Desai, B. M. (1974). New cultivars of perennial Portulaca through gamma radiation. Indian Horticulture 19(2): 19, 23.
Brief descriptions are given of the flower characteristics of 5 P. grandiflora mutants.

(1075) Koreman, P., A. Cameron, et al. (1996). Manipulating photoperiod for height control. GrowerTalks 60(10): 58, 60.
The use of a limited induction photoperiod (LIP), in which plants are exposed to a limited number of inductive long days and then returned to normal days, for height control of perennials was investigated. Plants were grown under long days for 2, 3, 4 or 5 weeks before transfer back to 9-h days for finishing. Height was reduced by LIP in Campanula carpatica cv. Blue Clips, Coreopsis grandiflora cultivars Sunburst and Sunray, Coreopsis lanceolata cv. Early Sunrise, Coreopsis verticillata cv. Moonbeam and Echinacea purpurea, but not in C. lanceolata cv. Baby Sun. Baby Sun and Sunray plants given LIP treatment had fewer buds at first flower than continuously lit controls. Below a critical number, fewer long days resulted in shorter plants but also delayed flowering. In another experiment, Early Sunrise plants were given

16 long days and then grown to flowering under 8 daylengths ranging from 9 to 24 h of light. As daylength after LIP treatment increased, plant height increased. Plants finished under photoperiods of 14 h or less had no delay in flowering but a significant reduction in height; the best quality plants were finished under a 12-h photoperiod. The height reduction appeared to be effective only on internodes on the vegetative portion of the plant.

(1076) Abraham, V. and B. M. Desai (1977). Induced tetraploidy in a perennial Portulaca mutant. Indian Journal of Horticulture 34(3): 301-305.
When cuttings of a gamma -ray induced 5-petal mutant of portulaca were treated with colchicine at 0.05% for 36 h some tetraploid branches with larger flowers were produced. Data are presented on the vegetative and floral characteristics of the tetraploid compared with the diploid plants.

(1077) Holcomb, E. J. and D. J. Beattie (1990). Growth retardants for perennials. Proceedings of the Plant Growth Regulator Society of America 17: 164-169.
In attempts to produce garden perennials as pot plants, the growth retardants daminozide, ancymidol, paclobutrazol or uniconazole were applied at various concentrations to 6 perennials (Liatris spicata cv. Kobold; Platycodon grandiflorus cv. Blue; Delphinium cv. Blue Spring; Coreopsis verticillata cv. Moonbeam; Lilium [maculatum] cv. Sunray and Astilbe cv. Avalanche). The plants were obtained as corms, root tubers, seedlings, rooted cuttings, bulbs or crowns, respectively, and were treated with the growth regulators as drenches or foliar sprays when actively growing. The results are tabulated. It was found that, apart from L. spicata, the flowering height of these species could be restricted if the appropriate retardant and rate of application was used.

(1078) Zimmerman, R. H. (1996). Commercial application of tissue culture to horticultural crops in the United States. Journal of the Korean Society of Horticulture Science 37(3): 486 - 490.
Commercial micropropagation (of orchids) started in the USA in 1965. The historical background of micropropagation in the USA, a description of the industry and the production of micropropagated plants (including foliage plants, fruit, ornamental and forest species, herbaceous perennial plants, and vegetables) in the USA are described.

(1079) Taylor, R. D., E. M. Smith, et al. (1990). Comparative costs of producing alternative plants in a three-acre perennial container nursery in Ohio--1989. OARDC Special Circular Ohio Agricultural Research and Development Center No. 135: 14-17.
The costs of producing container grown perennial plants in Ohio are compared, differentiated by plant group. Total annual costs per saleable plant in a three-acre perennial container nursery by plant group were $1.17 per quart container (4 inches X 4 inches X 4 3/4 inches) for perennials propagated from seed, £1.24 per quart container for perennials propagated from cuttings, £1.49 per quart container for perennials propagated from crown divisions, $1.95 per three-quart container for chrysanthemums, and $0.99 per cell (16 cell/flat) for herbs, and averaged $1.21 for all species. Fixed costs averaged 49% and variable costs 51% of the total.

(1080) Indyke, H. (1978). Chemical renovation of large college campus. Weeds, Trees and Turf 17(3): 34-38.
Estimates of $59 290 for reseeding 35 acres and $243 939 for laying turf promoted interest in chemical renovation using glyphosate and reseeding. Glyphosate applied in August gave complete control and the reseeded grasses had established by the end of October. The herbicide and grass seed cost $5950. Renovation of turf composed of coarse grasses and broad-leaved weeds in New Jersey was carried out without soil disturbance, using glyphosate on 15 August and overseeding 7 days later with a mixture of smooth-stalked meadow grass [Poa pratensis], Chewings fescue [Festuca rubra] and perennial ryegrass [Lolium perenne]. Turf was well established by the end of October.

(1081) Keever, G. J. (1994). BA-induced offset formation in hosta. Journal of Environmental Horticulture 12(1): 36-39.
Axillary and rhizomic budbreak and offset formation in Hosta sieboldiana were promoted by a single foliar application of BA at 125-4000 p.p.m. or drench application at 5-120 mg a.i./0.8-litre pot, compared with an untreated control. Based on offset counts following various periods of dormancy, optimal foliar rates ranged from 2000 to 3000 p.p.m. and drench rates from 20 to 40 mg a.i./0.8-litre pot. Foliar application of 3000 or 4000 p.p.m. BA or drenching with 80, 100, or 120 mg a.i./pot induced marginal necrosis within 2 weeks after treatment; however, growth following dormancy appeared normal. Generally, growth indices were not affected by foliar application of BA, but decreased with increasing rates of drench-applied BA.

(1082) Herrick, T. A. and L. P. Perry (1995). Controlled freezing of twenty-three container-grown herbaceous perennials. Journal of Environmental Horticulture 13(4): 190-193.
Twenty-three containerized herbaceous perennials were acclimatized to ambient outdoor temperature and photoperiod until 19 Nov., when they were moved into a greenhouse and held at 3°C until 15 Feb. At that time, plants were exposed for 30 min to a range of subzero temperatures, and returned to the greenhouse for forcing. Plants were rated for survival and saleability following 6 weeks regrowth at 15°, using a subjective scale of 1 to 5 (1 = worst, 5 = best, 3 and above considered saleable). Of the 23 perennials studied, 15 survived after exposure to at least -8°, however, 40% of the species and cultivars surviving at this temperature sustained a level of injury which rendered them unsaleable. Most plants were rated saleable at treatment temperatures 3-6° warmer than their respective lowest survival temperatures (LST's). Phlox cultivars Chattahoochie and Morris Berd, and Tiarella cv. Laird of Skye remained saleable after exposure to -11°. Campanula takesimana, Heuchera americana cv. Dales Strain, Penstemon fruticosus cv. Purple Haze, Rosmarinus officinalis cv. Arp, Tiarella cv. Running Tapestry, and Tiarella cordifolia cv. Slick Rock remained saleable after exposure to -8°. Erodium reichardia cv. Roseum, Hebe macrocarpa cv. Margaret, and Verbena cv. Homestead Purple remained saleable after exposure to -5°. Only the unfrozen controls of Houttuynia cordata cv. Chameleon and Thelypteris kunthii remained saleable. Treatment means for Ceratostigma plumbaginoides were not significantly different and all 6 Hibiscus cultivars (Blue River II, Disco Belle Pink, Disco Belle Rose Red, Disco Belle White, Lord Baltimore and Southern Belle) failed to survive any of the temperature treatments. In general, plants showed a gradual decline in saleability with decreasing temperature.

(1083) Whittall, J., A. Liston, et al. (2000). Detecting nucleotide additivity from direct sequences is a SNAP: an example from Sidalcea (Malvaceae). Plant Biology 2(2): 211-217.
Superimposed nucleotide additivity patterns (SNAPs) were detected from direct sequences of the nuclear ribosomal DNA internal transcribed spacers in a complex of perennial Sidalcea species from the Pacific Northwest of the United States. Although only 2.8% sequence variation exists among the eight ITS accessions, parsimony analysis identified two distinct lineages within this complex consistent with known ploidy levels. Six SNAPs were identified in a known tetraploid S. virgata, suggesting allopolyploid origins from diploid S. virgata and one of two

hexaploid Sidalcea species. A dosage effect detected at all six SNAP sites is consistent with the unequal sized parental genomes of allopolyploid S. virgata.

(1084) Cripps, R. W. and H. K. Bates (1993). Effect of cover crops on soil erosion in nursery aisles. Journal of Environmental Horticulture 11(1): 5-8.
The effectiveness of soil erosion control of various vegetative aisle covers was evaluated using Universal Soil Loss Equation (USLE) type plots. Lespedeza cuneata cv. Appalow, crimson clover (Trifolium incarnatum) and perennial ryegrass (Lolium perenne) aisle treatments and a clean till plot were established on a 5% slope Typic Paleudult soil. Previously established trees of cv. Indian Magic crabapple and silver maple (Acer saccharinum) were grown parallel to the slope in the centre of each plot. Runoff from the clean-till aisle resulted in the greatest sediment concentration, runoff volume and sediment runoff. There was little difference between the runoff from crimson clover and perennial ryegrass. The lespedeza aisle cover had the highest runoff volume of any vegetative aisle cover. However, runoff sediment concentration and sediment runoff were least from lespedeza-covered aisles.

(1085) Finnerty, T. and J. M. Zajicek (1992). Effects of seed priming on plug production of Coreopsis lanceolata and Echinacea purpurea. Journal of Environmental Horticulture 10(3): 129-132.
Seeds of C. lanceolata and E. purpurea were primed in 50 mM potassium phosphate buffer (KH2PO4 + K2HPO4, pH 7.0) to determine whether improved plug production of these herbaceous perennials would result. Experiments were conducted at 2 locations: Texas A&M University (TAMU), College Station, and Buell's Inc., Cibolo, Texas. Location had a significant effect on emergence, with both species having greater emergence percentages at Buell's Inc. than at TAMU. This effect is attributed mainly to watering systems and plug aeration. Priming significantly increased emergence of only E. purpurea grown at TAMU. Seedlings from seeds primed in 50 mM K salts for 9 days at 15°C had more than twice the emergence percentage (47%) of seedlings from nonprimed seeds (21%). Priming did have a significant effect on the root development of both species. E. purpurea seedlings from primed seeds had a 44 to 51% increase in total root area compared with nonprimed seeds. C. lanceolata seedlings from primed seeds had up to an 85% increase in root area compared with seedlings from nonprimed seeds. In plug systems, relatively well-developed root systems may result in positive growth response after transplanting.

(1086) Iles, J. K., N. H. Agnew, et al. (1993). Evaluation of structureless overwintering systems for container-grown herbaceous perennials. Journal of Environmental Horticulture 11(2): 48-55.
Five structureless overwintering systems were evaluated in 1989 and 1990 for temperature moderation and protection of 18 species of container-grown herbaceous perennials from low-temperature injury. Two light-excluding treatments (30-cm thick layer of straw between 2 layers of 4-mm thick, white polyethylene, or 18-cm deep, in-ground beds protected with 1 layer of 4-mm thick, white polyethylene and 30 cm of woodchips) provided the greatest moderation of low winter and high early spring temperatures, but also resulted in severe etiolation. A bonded white polyethylene/microfoam overwintering blanket (thermoblanket) with translucent properties provided comparable plant survival percentages despite dramatic temperature extremes recorded beneath this cover and, in late winter, created an environment conducive to moderate plant growth without formation of etiolated tissue. Based on shoot DW measurements, the species deriving the most benefit from winter covers, regardless of covering treatment, were Coreopsis verticillata cv. Zagreb, Delphinium elatum cv. Pacific Hybrid, Physostegia virginiana cultivars Pink Bouquet and Summer Snow, Sedum cultivars Autumn Joy and Brilliant, and Veronica spicata cv. Icicle.

(1087) Hitchmough, J. (1995). Perennial pleasures in the urban sward. Horticulturist 4(2): 2-9.
The selection of herbaceous perennials for meadow or tussock grasslands on urban sites, their establishment and management and the control of self-seeding are discussed.

(1088) Perry, L. P. and T. Herrick (1996). Freezing date and duration effects on regrowth of three species of container-grown herbaceous perennials. Journal of Environmental Horticulture 14(4): 214-216.
Seedlings of Aquilegia cv. McKana's Giant, Dianthus deltoides cv. Vampire and Lavandula angustifolia cv. Munstead Dwarf were transplanted from 400 cell-size plugs to 400-ml containers and grown in a greenhouse at day/night temperatures of 25°/20°C until 10 October 1995. At that time greenhouses were programmed for ambient outdoor temperatures, but maintained above 3°C at night. Plants were exposed in controlled programmable freezers to temperatures of -5, -8, -11 and -14° on 15 November 1995 and 1 January 1996. Plants were allowed to remain at each temperature for either 30 or 120 minutes. Plants were then returned to the greenhouse, and rated for survival and salability following 6 weeks of regrowth at 15°. The rating scale was subjective and ranged from 1 to 5 (1 = worst, 5 = best, 3 and above considered salable). Regrowth means of all 3 species declined as treatment temperatures decreased. Although freezing date had a significant influence on regrowth quality of Aquilegia and D. deltoides, only freezing duration influenced D. deltoides regrowth. Neither factor significantly influenced regrowth quality of L. angustifolia. Treatment temperature and its interaction with freezing date or duration was statistically significant for all 3 species. All plants remained marketable following exposure to -11°C.

(1089) Mackay, W. A., T. D. Davis, et al. (1996). Factors influencing seed germination of Lupinus perennis. Journal of Environmental Horticulture 14(4): 167-169.
Seeds of Lupinus perennis (perennial lupine) were subjected to a variety of scarification and temperature treatments. Without scarification, <15% germination was observed within 1 week. Germination increased quadratically as the duration of acid scarification time increased. After 15 min of scarification, nearly 90% of the seeds germinated and nearly 100% germination was obtained after 45 min of scarification. Nicking the seed coats with a razor blade resulted in 100% germination. In contrast, soaking seeds in water at 22°C for 24 h failed to enhance germination. Total germination of scarified seeds was >80% between 21 and 29° within 54 h. The most rapid germination occurred at 24 to 29°. At 32°, total germination was reduced to approximately 60%. At temperatures _ 35°, total germination was reduced to less than 4%. Germination occurred equally well in the light or dark.

(1090) LaMondia, J. A. (1997). Management of Meloidogyne hapla in herbaceous perennial ornamentals by sanitation and resistance. Journal of Nematology 29(4 Supp): 717-720.
Root pruning of bare-root plants was investigated as a means of reducing spread and establishment of M. hapla. Plants previously inoculated with 10 000 eggs/plant were root-pruned to remove either a portion or most of the fibrous root system without removing underground stems, buds, tubers or tuberous roots. Root pruning of Aconitum, Ajuga, Anemone, Geranium and Trollius significantly reduced or eliminated M. hapla galls and egg production in plants, 1 to 4 months after propagation. Planting M. hapla-resistant plants such as Rudbeckia and Aster into pots

infested with 10 000 eggs/pot eliminated M. hapla populations after 2 to 6 months of growth. Tomato plants grown after Rudbeckia and Aster were free of galls and eggs, while bioassay tomatoes grown after susceptible plants such as Coreopsis, Primula and Lobelia were heavily galled with a large number of egg masses. These results demonstrated the potential of sanitation and resistance for management of M. hapla in perennials.